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Imperial Institute of Agricultural Research, Pusa

(Including the Reports of the Imperial Dairy Expert, Physiological Chemist and Sugarcane Expert)

1933-34

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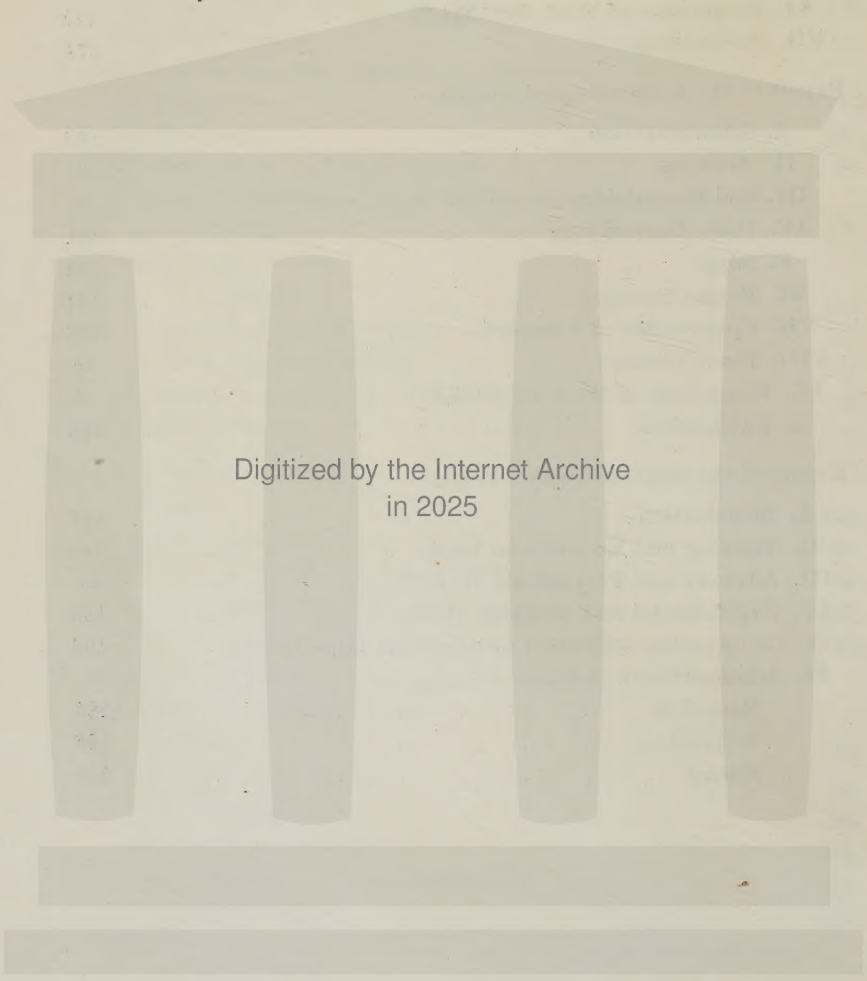

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Scientific Reports of the Imperial Institute of Agricultural Research, Pusa

(Including the Reports of the Imperial Dairy Expert, Physiological Chemist and Sugarcane Expert)

1933-34

REPORT OF THE DIRECTOR

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I. GENERAL

The outstanding feature of the year under review was the occurrence of a very severe earthquake at about 2-10 P.M. on the 15th January, 1934. The shock which was one of the most severe ever recorded in India, caused wide-spread damage in Bihar. The epicentre of the shock and the zone of greatest damage was approximately on a line running from Motihari through Muzaffarpur to Monghyr and practically passed through Pusa. The Phipp's Laboratory suffered very severely, both wings being wrecked and the structure of the main building being so badly damaged as to be irreparable. All laboratories in the Phipp's Laboratory had to be vacated and arrangements made to carry on the scientific work on a reduced scale in such small buildings as were available and habitable. Work in the chemical, mycological and entomological sections is now proceeding under great difficulties of space and equipment.

A considerable amount of apparatus was broken and damaged and will have to be replaced, but whole of the library was saved. The decision of the Government of India to transfer and rebuild the Institute at Delhi will place the Institute in a position in which it will be much more efficient and of much greater service to Indian agriculture.

II. RESEARCH AND PROGRAMME OF WORK

Soil fertility

Indian soils have, in general, a low content of nitrogen, and the ryot uses little or no nitrogenous manures. Though climatic conditions result generally in active nitrification, the average crop yields are low and the maintenance of an adequate supply of nitrogen in Indian soils constitutes one of the important problems facing agricultural research workers. Studies of the nitrogen balance sheet, the factors influencing nitrogen fixation, and practical measures such as the use of leguminous crops and green manures are, therefore, of great interest and importance.

The experiment to determine the influence of leguminous crops in conserving the soil nitrogen when grown in mixture or in rotation with a cereal has now run for four years, and, as in previous years, a gain in soil nitrogen was noticed in all plots in both the *kharif* (summer) and *rabi* (winter) series after taking into consideration the nitrogen removed by the crops. The highest gain in the *kharif* series was 415·8 lb. per acre with a mixed crop of maize and *urid* (*Phaseolus radiatus*) and in the *rabi* series of 364 lb. with a mixed crop of barley and field peas. A statistical analysis is being made of the economic return obtained as well as the nitrogen gained by the soil with a view to ascertaining which system of cropping is superior from both points of view.

Investigations in the laboratory have shown that changes in the seasonal temperature affect the nitrifying flora in the soil to a great extent and cause two periods of depression in May and November. Soil samples taken in June are comparatively richer in nitrifying organisms : they nitrify both *sarson* cake and ammonium sulphate completely within four weeks. Silt thrown out by the earthquake has not been found to differ very much from the normal Pusa soil, but the sand is poorer in total nitrogen and nitrifying flora.

The field experiment started three years ago to find cheaper but equally efficient alternatives to sann-hemp as a green manure has not yielded results in favour of either *urid* (*Phaseolus radiatus*) or soybean (*Glycine hispida*). Whether whole sann-hemp plants are ploughed in or only the tops are buried and the stems are utilized for extracting fibre, the succeeding crop of wheat is better and the residual effect more lasting. The difference in the value of produce obtained with the two methods of utilizing sann-hemp as a manure is not significant. The experiment on the possibility of securing green-manure from land already growing another crop was again carried out. As in previous years, Mexican sunflower (*Tithonia diversiflora*) was planted in land carrying a crop of onions. Expressed in yields per acre, 116·8 maunds of onions and 93 maunds of

sunflower were obtained as against 125·9 maunds of onions from control plots growing that crop alone. The low yields of sunflower, as compared with previous years, can be ascribed to the fact that the earthquake delayed planting and disturbed the arrangements for irrigation. The effect of burying in sunflower is marked on the yields of succeeding *kharif* and *rabi* crops but the economics of the cropping system as a whole are yet to be worked out.

Katwa sewar (*Hydrilla verticillata*), an acquatic plant growing abundantly in river beds, having been found to ferment quickly in the soil, is being tried as a manure. In preliminary trials, plots manured with *sewar* have yielded 44·5 per cent. more corn than those receiving farmyard manure.

Apricot seed-cake has proved an efficient nitrogenous manure for soils which are deficient in this constituent, and especially so in agricultural lands in the neighbourhood of Solon in Simla Hills where it is available in plenty but is at present used as a fuel. The application of 80 lb. of nitrogen per acre produces the maximum yield of wheat whether the soil used is from Pusa or Solon, but the residual effect in Pusa soil is not significant unless the dose is raised to 100 lb.

Among other investigations bearing on the maintenance or improvement of the fertility of soils may be mentioned those intended to elucidate the lime requirements of acid soils of Assam, the limiting factors of phosphate and potash requirements in calcareous soils, the relative availability of natural and artificial phosphates in calcareous soils, and the apparent ineffectiveness, or even depressing effect, of potassic fertilizers in Pusa soil. Pot experiments designed to determine the depth of soil at which superphosphate can most profitably be applied in Pusa soil have shown that best results with a crop of mustard are obtained when the manure is placed four inches below the surface.

Improvement in yields and quality of Agricultural Produce

The plant breeding work at the Institute is directed towards providing the Indian cultivator with high yielding types of crops and improving the quality of agricultural produce. The quality of agricultural produce depends upon its uniformity, its purity and its possession of some intrinsic property, *e.g.*, high gluten content in wheat, oil content in linseed, disease resistance in pigeon-pea. This section of the report is mainly concerned with what is being done at Pusa and Coimbatore in this respect.

Wheat.—Of the total acreage of over 30 million acres under wheat, about 3 million acres are under the celebrated Pusa wheats—Pusa 4, Pusa 12 and Pusa 52—which are superior in yield and quality to the *desi* wheats. In addition, two new wheats have

recently been produced, one of which (Pusa 111) has been tested in England and pronounced equal in quality to the best Canadian wheat ; in this new wheat India possesses a grain which may enable her to compete in the export trade. The other wheat (Pusa 114) has proved extraordinarily successful in the area under the Sukkur Barrage and, on account of its disease resistance and quality, has sold in Sind during the year under report at a premium of 12 per cent. over the local wheats. The breeding work at Pusa has yielded other strains which promise to meet the special requirements of certain areas. In a season which was characterized by an unusually severe incidence of rust, Pusa 101, a cross between Muzaffarnagar and Pusa 22, proved an outstanding yielder, acreage yields under such varying conditions as at Pusa and Meerut being 2,584·4 and 2,715·4 lb. respectively. It is reported to have possibilities for spreading in Bhopal State where a rust-resistant wheat is badly required. Through its freedom from lodging and black rust on the Karnal Sub-station, Pusa 80-5 has come to be widely appreciated in the Punjab where its seed is much in demand by the local Agricultural Department. Although most of the hybrids obtained from crosses between the Australian variety Federation and Pusa 4 and Pusa 52 have not been found superior to the Indian parents in yield, some of them nevertheless possess certain desirable features such as resistance to disease which may render them of agronomic value. Two of them, designated Pusa 120 and Pusa 165, are under test on various farms in the Punjab and in the United Provinces and the results are being awaited with interest.

Oats.—The 11 hybrids fixed by crossing Pusa types with Abundance and Scotch Potato were tried for the third time simultaneously at Pusa (without irrigation) and Karnal (under irrigation) against the standard Pusa types B. S. 1 and B. S. 2. The accumulated results of three seasons' trials at each place show that the five highest yielders are B. S. 2, B. S. 1 and Hybrids C. J. and G which are ranked in this order but B. S. 1 and Hybrids C. J. and G are not statistically different from each other and may all be classed as yielders of the same order. Amongst these five oats B. S. 2 is statistically superior to hybrid G only and not to any others. Hybrids A, B, H and K, on the other hand, have not done well and must be ranked as indifferent yielders. Favourable reports regarding the yielding power of B. S. 1 and 2 and Hybrids C and J have been received from many parts of India where they have been tried during the year under report. At the Byreah Farm of the Bettiah Raj in North Bihar, B. S. 1 significantly out-yielded hybrids C, F and J.

Barley.—All the 24 types of barley isolated at Pusa having been found susceptible more or less to a serious disease caused by *Helminthosporium*, which is only partially controlled by seed treatment, a study of the inheritance of resistance to this disease has been

linked up with breeding work. The present indications are that resistance to disease is dominant to susceptibility.

Paddy.—In a preliminary yield trial with the most promising of 123 types isolated, one autumn paddy (Type 18) and three winter paddies (Types 24, 31 and 52) have been picked out as being worthy of large seed tests.

Linseed.—The yield trial experiments intended to test certain hybrids obtained by crossing the high-yielding Pusa types of low oil content with low-yielding Central Indian varieties of high oil-content against standard Pusa Type 12 were vitiated by a severe incidence of rust (*Melampsoralini*). With a view to combining in one type high yield, high oil-content and resistance to rust, certain bold-seeded Australian linseeds which are immune to rust have been crossed with the high-yielding indigenous types and fixed hybrids. The best of these hybrids will it is hoped make India, with the Ottawa preferences in her favour, retain an even larger share of the export trade to the United Kingdom and of the quality market of the Continent. The Crop Planning Conference considered that India could probably increase her linseed area by two million acres, but that progress would depend largely on the spread of improved types.

Sesamum.—Cross-breeding has been resorted to for producing a highyielding, white-seeded strain : the trade prefers white-seeded types for the lighter-coloured oil they yield.

Gram.—Though at Pusa and at Karnal, Type 58 failed to repeat its performance of previous two years in out-yielding Type 17, it, along with Types 51, 54 and 55, did significantly better than the other established Type 25. Type 58 is, however, reported to have given higher yield than T. 17 on various other experiment stations. The hybridization work in progress at Karnal continues to give information on the inheritance of various characters.

Pigeon-pea.—In a yield trial with 10 promising types isolated, Types 24 and 64 again proved significantly better yielders than local seed. At Sabour where Pusa Types 15, 16, 41, 50, 80 and 82 were grown, the wilt-resistant Type 80 occupied the first position, while Types 24 and 51 did fairly well on the Sepaya Farm. Type 51 is reported to have shown resistance to frost injury on the Gwalior Farm.

Indian hemp.—Pusa Types 1 and 2 of *ganja* were cured for the first time during the year under review. Type 1 appears to be a very promising strain for the production of the drug and seed is being multiplied for large-scale trials. About 160 lb. of seed were obtained from a crop of this type in an area of about one-fourth of an acre.

Tobacco.—As stated in previous reports, the problem of meeting the ever-increasing demand for a higher and brighter tobacco has

been tackled in the Botanical Section by crossing a local type (Type 28) with an American Adcock and fixing certain hybrids which are breeding pure within narrow limits. The large growings of one of these hybrids (Type 142) for flue-curing this year produced a fine crop and some very good quality leaf was cured before the crop was damaged by a hailstorm in the middle of January. Some 1,500 flue-curing barns worked on the principles evolved at Pusa are now in operation in districts which are suitable for this industry, *viz.*, Guntur in Madras, Saharanpur in the United Provinces and in North Bihar, and the capital expended by commercial concerns in constructing them is approximately 15 lakhs of rupees.

Indigo.—In the course of experiments carried on in the Chemical Section with the object of bringing the natural indigo paste into a colloidal state and maintaining it in such state without fermentation, sodium salicylate has proved a better preservative than sodium carbonate in that subsequent heating in the air oven can be dispensed with. Natural indigo paste as available immediately after the *mahai* mixed with 5 per cent. sodium salicylate and kept in sealed tins has been found after four months unchanged and free from fermentation. It is now proposed to give dyeing trials with indigo paste preserved with sodium carbonate and sodium salicylate and see how they compared with ordinary natural indigo cake as marketed at present.

Sugarcane.—The improved types of thin and sub-tropical canes bred at the Imperial Cane-breeding Station at Coimbatore covering as they do half the total area under the crop have raised the average yield per acre for the whole of India from eleven to fifteen tons. They have rendered possible the enormous development of the white sugar industry in North India which promises to make India in the near future independent of foreign imports. Certain of these sub-tropical canes, particularly Co. 213, Co. 281 and Co. 290, are finding favour even in typically tropical parts of India as well as in foreign countries such as Argentine, Louisiana, South Africa and Australia. The last two mentioned would appear to have revealed unsuspected resources of both drought and disease resistance, outrivalling a cane of such outstanding merit in this direction as Uba. The remarkable way in which Co. 223 is working its way in the Kangra District of the Himalayas and at altitudes of over 4,000 feet above sea level is a noteworthy development. Among the new canes, Co. 313 and Co. 331 continue to fulfil their early promise, and there are indications that Co. 349 might prove one of the canes of the future. The breeding of new seedlings which will give heavy yields under a wider range of conditions than those for which the present popular Coimbatore varieties are suitable is being actively carried on and the technique of breeding is being gradually perfected. This work is expected to be accelerated with the development of

the sub-station at Karnal financed by the Imperial Council of Agricultural Research. Last two years' experience has shown that maximum advantage of the sub-station can be obtained by effecting the desired crosses at Coimbatore at the beginning of the arrowing season and transporting the young seedlings to Karnal for planting at the usual time for canes in the tract. Thus handled, the seedlings show normal growth and allow of preliminary selections being made at the end of their first year at Karnal.

Among the first batch of thick canes distributed three years ago, there are some which have already begun to attract attention in agricultural stations in North as well as in South India. Co. 408, 413, 407 and 402 are doing well at Karnal (Punjab), Shahjahanpur (United Provinces), Jorhat (Assam) and Padegaon (Bombay Presidency) respectively. With the distribution of 11 more seedlings during the year under report the number of tropical canes under trial has been brought up to 32.

Sugarcane-sorghum hybrids are still being tested and a few of them may prove to be the earliest to mature during the ripening period for canes in that area. Particularly Co. 356 has shown promise of usefulness in more than one North Indian Station. In the Madras Presidency where these hybrids have been planted and analysed every month, some of them are reported to attain a purity of 85 and over in about 200 to 220 days from the time of planting and tend to improve in quality for nearly 100 days afterwards. Further, " the juices of sorghum hybrids at the point of their maximum efficiency were decidedly richer than those of other Coimbatore canes ".

At Pusa, an independent area of land measuring 150 acres is mainly devoted to sugarcane experiments. The testing of new Coimbatore canes for yield and other characteristics, tonnage trials with selected varieties, manurial experiments and general problems of cane cultivation form the basis of the work. The impending trials of Co. 281 as a semi-irrigated cane to replace Co. 213 and of Co. 331 as a heavy tonnage late ripening cane for April crushing had to be postponed indefinitely owing to the dislocation caused by the earthquake of January 1934, but a mill test was carried out on 19th November 1933 at the Samastipur Central Sugar Factory with Co. 299 which promised to be an early cane like Co. 214 without its bad agricultural habit and poor tonnage yields. The mill trial results have shown that a definite saving in raw material cost can be effected by the substitution of Co. 299 for Co. 214.

Plant Diseases

The work on the mosaic disease of sugarcane financed by the Imperial Council of Agricultural Research has yielded useful information on the nature of mosaic virus and the organisms associated

therewith, for details of which reference is invited to the Report of the Imperial Mycologist. The experiment on the effect of mosaic on the tonnage and juice of sugarcane was extended to Patna and Cawnpore, and it would appear from the following figures that the effect was marked and significant under different soil conditions and that the loss was more in the irrigated crops at Patna and Cawnpore than at Pusa where no irrigation was given.

Percentage loss due to mosaic

	In tonnage.	In calculated juice.
Pusa	11·9	12·94
Patna	19·0	19·40
Cawnpore	15·9	17·08

Amongst the new diseases of sugarcane under study may be mentioned the red stripe disease reported last year which is now known to occur throughout sub-tropical India, a stinking rot of bacterial origin observed for the first time at the Sugarcane Research Station at Mushari in Bihar, and a seedling disease found in the nurseries at Coimbatore, the symptoms of which are like those of foot-rot caused by *Helminthosporium sativum* in wheat. Dusting with RV_3 sulphur had no beneficial effect on plants affected with top-rot disease caused by *Fusarium moniliforme*.

Attempts to combat the stem-rot of *Hibiscus sabdariffa* caused by *Sclerotinia sclerotiorum*, which appears in January, by early sowing met with disappointing results, for whether the crop was sown in April, May or June, it was ready for harvest by the end of February. Ploughing the soil rather deep after harvesting appears to be one of the methods of controlling the disease, for it is brought about by the ascospores that are formed about December when the cold weather sets in.

As a certain percentage of wilt of sann-hemp is caused by *Fusarium vasinfectum* carried by seed, disinfection of seed before sowing with either uspulun (0·25 per cent.) for 30 minutes or mercuric chloride (1—1,000) for 10 minutes is indicated.

Though seed treatment with uspulun gave better results than other fungicides employed, *viz.*, copper carbonate, ceresan and formalin, it was not able to check altogether the bunt disease of wheat caused by *Tilletia indica*. As the bunt spores are well protected by the pericarp covering, it is likely that hot water treatment may be more effective than that with a fungicide.

Covered smut of oats (*Ustilago kolleri* Wille) was brought under complete control by treating the seed with formaldehyde using the dry spray method. In a hundred-acre area sown with treated seed, only two smutted heads were seen, while smut ranged from 1·5 to 16·9 per cent. on a 25-acre plot sown with untreated seed.

The experiment to test the comparative resisting power of 24 types of Pusa barleys to *Helminthosporium* was continued, and besides uspulun, ceresan was also tested as a seed disinfectant. Though both fungicides were found equally good in controlling foot and root-rots, neither prevented destruction of leaf surface which apparently is due to secondary infection taking place by means of air-borne spores. Seed treatment with formalin was not so effective in controlling the smut disease of barley caused by *Ustilago hordei* as that with uspulun and ceresan.

The investigation into the foot-rot disease of *Piper betle* in Bengal was concluded after it had been conclusively established that growing the vines above the flood level, clean culture and timely applications of Bordeaux mixture and Kerol controlled the disease.

A study of the fungus flora of soil in which pigeon-pea had been grown continuously for ten years revealed the presence of *Fusarium vasinfectum* up to a depth of two feet. Among other fungi commonly found were species of *Aspergillus Necosmospora vasinfectum*, *Mucor* sp. and three Ascomycetes. The number of colonies of fungi decreased with the increase in depth.

Among other diseases under investigation may be mentioned those of wheat caused by *Helminthosporium*, *Ustilago* and *Puccinia* the sclerotial diseases of rice, leaf blight of gram caused by *Mystrosporium* sp., stem and root-rots of tobacco and the *phurki* disease of *Amomum subulatum*. Further survey of diseases of fruit trees in British Baluchistan was undertaken during the year and several fungi were recorded there for the first time.

Insect Pests

As in previous years, sugarcane borers and other insect pests of sugarcane received considerable attention in the Entomological Section. In a detailed examination of the previous year's sugarcane crop covering an area of 1·95 acres, made from the 17th March to the 11th May 1934 with a view to determining the incidence of the major pests of sugarcane, it was found that the percentage of healthy canes varied from 21·10 to 45·41 per cent. The percentage of infestation was observed to vary as follows in different cases :—

	Percentage of infestation.
Top-shoot borer (*Scirpophaga nivella* Fb.) . .	11·55—35·37
Stem-borer (*Chilo zonellus* Swinh., *Argyria stictic-raspis* Hmp. and *Diatraea venosata* Wlk.) .	2·33—8·01
Root borer (*Emmalocera depressella* Swinh.) .	3·2—11·55
Termites	1·48—7·82

A similar survey made of the mosaic tonnage experimental plots at the time of the harvest in February-March 1934 revealed the

damage by the top-shoot borer among mosaic infested canes to be 17·25 per cent. as against 12·22 per cent. in mosaic-free plots. Definite observations on the bionomics of *Scirpophaga nivella* Fb. have shown that the borer hibernates in cane as larvæ till the third week of February, that pupation begins in the last week of February, and that the first moth emerges about the 28th February. The other important sugarcane pest under observation is *Pyrilla* spp. the incidence of which was noticed to increase by the middle of June when oviposition on a large scale took place.

Hand-picking, trenching and poisoned baits were adopted against *Agrotis ypsilon* Rott which did considerable damage to peas, mustard and linseed crops. When the infested fields were flooded, the caterpillars were brought up to the surface and picked off by birds which came down in swarms. Light spraying with naphthaline emulsion had a considerable effect on unrestricted oviposition of the pea stem *Agromyzid* which infested experimental plots. The incidence of *Myzus persicae* Sulz. on peach and of *Papileo demoleus* Linn. on *Citrus* spp. was successfully controlled by spraying with nicotine sulphate and lead arsenate respectively.

The probable transmission of the crinkly leaf disease and the yellow mosaic disease of tobacco by insect agency is being investigated, and various stomach and contact poisons are being tried for their relative efficacy against cockroaches.

The life-histories of about 40 insects were studied partly or fully, and a survey of the various insects causing damage in the fruit orchards of British Baluchistan was continued.

The Spread of Improved Varieties of Crops

During the year under report, the Botanical Section and its Sub-station at Karnal and the Agricultural Section at Pusa distributed to Provincial Departments of Agriculture and to private growers the following quantities of seed of improved varieties :—

55,037 lb. of wheat
42,650 lb. of oats
3,168 lb. of barley
1,128 lb. of paddy
12,001 lb. of gram
1,298 lb. of pigeon-pea
778 lb. of linseed
165 lb. of *ganja* (Indian hemp)
23 lb. of tobacco
777,894 lb. of sugarcane setts
and 3,104 lb. of maize and miscellaneous.

The Sugarcane Breeding Station at Coimbatore supplied the Sugarcane Research Station at Shahjahanpur with 5,000 cane seedlings

with a view to exploring the possibilities of selecting and rejecting new seedlings in sub-tropical India even in the nursery stage. In addition, over 200 packets of seed canes were sent to about 30 places in India. The above figures by no means represent the spread during the year of the improved varieties tried at Pusa and Coimbatore, for the distribution of improved seeds is mainly carried out by local Departments of Agriculture who obtain yearly relatively small quantities of seed from Pusa and multiply them for distribution to ryots. In fact, the actual areas under improved varieties of wheat and sugarcane run into millions of acres.

Agricultural Machinery

Further experience with the Lanz Bulldog 15/30 H. P. tractor, which is of the semi-Diesel type, has shown that the installation of a cylinder liner in this model is an essential. The Marshall semi-Diesel 15/30 H. P. tractor purchased in 1932 has been exchanged with the new 18/30 H. P. model in which the fuel pump cam and sleeve are solid which is a distinct improvement. A fresh addition to the test fleet is a 9/18 H. P. Farmall row crop tractor in which the ploughing capacity is subordinated in design and construction to row crop work : it is a tractor which can intercultivate and ridge up as well as plough two furrows, while a tractor primarily constructed to plough cannot do row crop work at all. It appears to be an exceptionally efficient design which will be of great advantage in all parts where the cost of labour is high.

A hand winnower was designed and completed to work with the bullock-gear thresher suitable for Indian conditions mentioned in last year's report. The complete outfit consisting of the thresher, the winnower and the bullock gear is being marketed by a well-known engineering firm for Rs. 1,000.

The Dunlop pneumatic equipment for bullock carts was fully tested throughout the season under loads of sugarcane varying from 40 to 60 maunds (3,280 lb. to 4,920 lb.) carted either to the railway station (6 miles) or direct to the mill (14 miles). It stood up to every test excellently and showed no sign of any wear and tear and reduced carting costs to a marked extent. Further tests are in progress to test the farm life of the tyres.

Cattle Breeding and Dairying

Pusa.—The new system of feeding and handling the Sahiwal pedigree herd introduced two years ago continued to function successfully : though the milch herd numbers were reduced from 80 to 69, the total milk yield rose from 2,99,990 lb. to 3,00,690 lb., and the average yield per cow per day increased from 17·9 lb. to 18·7 lb., the highest average yield of 22·0 lb. being recorded in April 1934. The " in milk " percentage of the herd stood at 66·2 after excluding

cows kept for breeding alone and 'draft' cows put aside for sale. A notable increase in the milk yield of heifers has occurred, the average figures for the last four months of the year under report being higher than those for the corresponding period of any of the previous nine years. The experiments in early maturity are giving equally encouraging results. One bull, which started service at 18 months, is of full average size and weight at the age of three years, and his calves also show no signs of deterioration. Despite their early age heifers going to bull are of full average weight.

Karnal.—Breeding work with two indigenous breeds, *viz.*, Hariana and Thar Parkar is being continued. Since 1923-24 when the foundation herds of these breeds were purchased, the average milk yield in both cases has increased by 50 per cent. and the lactation period has been extended by about 25 per cent. Systematic recording of fat percentage in the milk of individual cows has shown that Harianas on an average yield 0·72 lb. fat as against 0·57 lb. given by Thar Parkars.

Bangalore.—In pursuance of the policy laid down by Government, the number of cattle with European blood is being gradually reduced and breeding work is concentrated on Scindi and Gir cattle. A systematic investigation of the method of making Surti cheese has been started and valuable data is being obtained with a view to standardizing the process.

Animal Nutrition

Another year's work by the Physiological Chemist on the influence of high and low protein feeding on milk production has shown that as cows on a low protein ration eat more fodder, the total food consumption is almost identical in both cases but that corresponding to the higher starch equivalent of a high protein ration there is a higher milk yield. Further tests are being carried out to confirm this question of milk yield and also to see how the cows tolerate the high protein level. Experiments are also in progress to determine the value for milk production of rations in which molasses replace weight for weight some of the usual concentrates.

As in previous year, various Indian coarse fodders were tested for digestibility, the main object being to determine the effect of advancing maturity upon composition and digestibility. It may now be taken as established that there is a relationship between the digestibility and protein content of fodders and that the digestion co-efficients for protein and carbohydrates increase as the protein content rises. A noteworthy feature of these trials was the high protein content and the high digestibility of Rhodes grass as compared with spear grass grown on similar land.

In view of the desirability of encouraging the production and utilization of legume hays, an investigation into the best method of preparing them, their digestibility and their effect on the nitrogen

balance is being carried on. There is practically no change in the chemical composition and only a slight diminution in the digestibility when lucerne is converted into hay, but even under ideal conditions of conversion the loss of dry matter, mainly through fermentation, is as much as 13 per cent.

The investigation the object of which is to determine comparative values of the mineral composition of grasses grown on selected typical soils in various parts of India, is beginning to yield important information. It has been noticed at Bangalore that of the three pure species of grass grown there, *viz.*, *Andropogon contortus*, *Cynodon dactylon* and *Pennisetum cenchroides*, *Andropogon contortus* gives in very deeply and thoroughly cultivated land a product abnormally rich in minerals, that *Cynodon dactylon* has a tendency to contain more lime than the other species which definitely exceeds phosphoric acid and that *Penniseturn cenchroides* contains less lime than *Cynodon dactylon* and at times seems to contain more phosphoric acid than lime which is unusual.

The experiment in which the Physiological Chemist showed that inorganic sulphate is assimilated by cattle has been extended to sheep. These animals too have been found to make use of inorganic sulphate to an appreciable extent.

In addition, various physiological studies are on hand, for which reference should be made to the Report of the Physiological Chemist.

At Pusa, feeding experiments are in progress to find out the exact food values of berseem hay and oats hay which have proved excellent dry fodders in maintaining a suitable ration for the dairy herd from April to June.

III. GENERAL ADMINISTRATION

Charge.—Dr. W. McRae, Director, was granted a year's extension of service from 26th May 1933. On his appointment as Offg. Agricultural Expert to the Imperial Council of Agricultural Research, Dr. F. J. F. Shaw officiated as Director from 28th April 1934 to 22nd June 1934, and was appointed substantively to the post from 23rd June 1934, when Dr. McRae retired from the Indian Agricultural Service having been granted a further extension of service for 28 days from 26th May 1934 and 22 days' leave on average pay from 1st June 1934 preparatory to retirement.

Staff.—Changes owing to absences on leave, etc :—

Mycological Section.—Dr. M. Mitra in charge from 28th April 1934 *vice* Dr. McRae on other duty followed by retirement from the Indian Agricultural Service on 23rd June 1934.

Physiological Chemist's Section.—Mr. A. V. Iyer upto 22nd November 1933 *vice* Mr. F. J. Warth on leave.

Sugarcane Station, Coimbatore.—Mr. N. L. Dutt in charge for one month from 6th September 1933 *vice* Rao Bahadur T. S. Venkatraman on leave.

Training.—During the year under report, four post-graduate students completed their training at Pusa : one—a two-year course in Botany and three—a one-year course in farm organization, farm management and general farm engineering. One student in Chemistry left for taking up an appointment without completing his course. Twenty-four students applied for admission to the new session beginning on the 1st November 1933, of whom 11 were nominees of either Provincial Selection Committees or Provincial Directors of Agriculture. Eight applicants were selected for admission : four in Botany, two in Chemistry, one in Entomology and one in General Agriculture. The number of post-graduates under training at the close of the year under report were as follows :—

Economic Botany and Plant Breeding	9
Sugarcane Breeding and Cultivation	3
Agricultural Chemistry	3
Entomology	2

Three post-graduate students were admitted to the fifteen-month post graduate course in Animal Husbandry, Animal nutrition and Dairying beginning on 2nd January 1934 : this course is divided between Bangalore, Karnal and Pusa.

Nineteen students sat for the Indian Dairy Diploma examination held at Bangalore in the last week of November 1933, of whom 15 qualified for the award of the Diploma. A new class with 21 students was opened in October 1933.

A number of students and post-graduate workers were also admitted for periods of work or training in various Sections of the Institute. Of the 15 British soldiers admitted to the Bangalore Dairy Farm for a six-month vocational course in practical dairying, only 11 remained for the full period : four left after four months as they were sent out of India. Another batch of 15 soldiers was admitted on 2nd February 1934 for a similar course. A special course in the flue-curing of tobacco organized at Pusa, which was attended by nine students deputed by seven Provincial Departments of Agriculture, was cut short owing to a severe hailstorm ruining the tobacco crop and the earthquake of 15th January 1934 damaging the flue-curing barn.

Library.—Publications received in exchange numbered 1,250, while 367 were purchased. Of the 1,667 publications issued on loan 154 were to scientific workers in the provinces and universities.

Hospital.—Medical relief was afforded to 325 in-patients and 8,400 out-patients in 1933. The total number of operations performed was 260. The health of the residents of the Estate was satisfactory and there was no serious outbreak of any epidemic disease.

IV. ACCOUNTS

The total expenditure for the Institute and its out-stations during the financial year ending 31st March 1934 amounted to Rs. 8,89,676 as against Rs. 9,09,599 for the previous year.

Name of Establishment.	Expenditure.*
	Rs.
General expenditure of the Institute including the Office of the Director, Power and Gas plants, the Medical and Estate Establishments	1,94,165
Agricultural Section	1,33,156
Botanical Section	53,579
Chemical Section	34,946
Mycological Section	26,774
Entomological Section	53,867
Bacteriological Section	35,935
Imperial Dairy Expert	29,354
Bangalore Dairy	1,10,830
Wellington Dairy	37,276
Karnal Farm	61,839
Physiological Chemist's Section	40,568
Sugarcane Station, Coimbatore	77,387
	8,89,676

* Provisional figures.

The cost of the Botanical and Sugarcane Sub-stations at Karnal and the Scheme for research on Mosaic and other diseases of sugarcane amounting to Rs. 21,414, Rs. 8,358, and Rs. 20,319, respectively, was met from funds from the Imperial Council of Agricultural Research.

The receipts of the Institute and its out-stations amounted to Rs. 2,24,515† as shown below :—

	Sale of dairy produce	Sale of Farm produce	Fees from Students	Miscellaneous Receipt	Total
Pusa Institute	11,659	10,717	4,262	9,680	36,318
Bangalore Dairy	77,046	162	3,485	11,732	92,425
Wellington Dairy	42,601	..	..	1,841	44,442
Karnal Farm	13,006	24,768	..	5,562	43,336
Coimbatore Sugarcane Station	..	..	..	7,994	7,994
Total	..	..	..	..	2,24,515

The figures are provisional.

REPORT OF THE IMPERIAL AGRICULTURIST

[Wynne Sayer, B.A., Dip. Agri. (Cantab.)]

I. CHARGE

I held charge of the Agricultural Section throughout the year.

Mr. Arjun Singh, Assistant Agriculturist was on leave on average pay for two months and sixteen days from the 7th July, 1933.

Mr. P. V. Krishna Iyer, M.A., was appointed as Statistician with effect from the afternoon of the 11th November, 1933.

II. TRAINING OF POST-GRADUATE STUDENTS

Messrs. Puran Singh, L. Ag., Abdul Rahim Khan, B.Sc. (Agri.) and J. D. Hill, Post-graduate students completed one year's training in general agriculture and farm organisation in the month of November, 1933. Mr. Imdad Ali Khan, B.Sc. (Agri.), Sugarcane Research Student, proceeded to Coimbatore in the same month to do a further year's training in sugarcane breeding under the Sugarcane Expert.

After completing one year's training at Coimbatore, Messrs. Khushi Mohamed, B.Sc. (Agri.) and Harbans Singh, B.Sc. (Agri.), joined this Section in November 1933, for their second year's study in sugarcane research. Mr. R. K. Tandon, B.Sc. (Agri.), M.Sc. was taken in for one year's training in farm organisation and general agriculture from the 2nd November, 1933.

III. SEASON

The total rainfall during the year from the 1st June 1933, to the 30th May, 1934, amounted to 51·70 inches against 37·16 inches in the corresponding period of the previous year. Exceptionally heavy rainfall (20 inches) in the month of July, 1933, accompanied by a flood affected the maize crop, the yield of which was very poor. The rain and flood in the last week of October put back the *rabi* sowings, especially berseem.

Earthquake.—A severe shock of earthquake occurred on Monday, January 15, 1934, at 2-13 P.M. accompanied by cracking of the earth and the discharge of water and sand from the fissures. The structure of almost all buildings was cracked. Two *bhusa* barns of the farm collapsed.

IV. SEED SUPPLY

The following seeds of improved varieties of crops were distributed :—

Variety	Quantity supplied lb.	Variety	Quantity supplied lb.
Wheat P. 12	6,697·0	Gram T. 17	2,633·1
,, P. 52	1,664·2	,, T. 25	966·9
,, P. 101	1,241·6	,, T. 58	246·9
,, P. 111	1,188·0		
,, P. 4	658·3	Lentil T. III—86	658·3
Barley T. 21	1,647·0	Soybean yellow	66·8
		Soybean black	25·7
Pea T. 14-1	205·7	Soybean chocolate	108·0
,, No. 1	41·1		
,, No. 2	41·1		
,, No. 4	8·2	Cowpeas	25·7
Maize No. 1	433·0	*Arhar* T. 51	374·4
,, No. 2	302·4	,, T. 15	164·6
,, No. 3	481·4	,, T. 24	205·7
		,, T. 80	82·3
Meth	313·7		
		Sugarcane Co. 285	25,920·1
Oats hybrid C	987·4	,, Co. 281	271,672·3
Oats hybrid J	165·6	,, Co. 299	86,373·8
,, B. S. I	39,498·3	,, Co. 331	326,360·6
,, B. S. II	1,152·0	,, Co. 214	44,290·5
		,, Co. 213	21,980·6
		,, Co. 343	1,296·0

V. CROP STATEMENT

The following statement gives the principal crops grown on the farm and yields obtained.

Crop	Variety	Area in acres	Yield in Mds.	
			Total	Average per acre
Maize corn	..	57·56	464—8—12	8·07
Maize—green fodder	..	170·51	22,863—36—0	134·09
Wheat	P. 4	11·10	71—28—8	6·46
,,	P. 12	16·22	254—0—4	15·66
,,	P. 52	38·98	407—22—0	10·45
,,	P. 111	11·21	122—25—14	10·94

Crop	Variety	Area in acres	Yield in Mds.	
			Total	Average per acre
Wheat	Other varieties	5·35	62—18—0	11·67
Barley	T 21	10·57	149—7—8	14·11
Arhar (*Cajanus indicus*) .	A 4	11·25	69—21—4	6·17
,, ...	T 15	10·00	99—11—12	9·93
,, ...	T 24	10·00	81—15—12	8·14
,, ...	T 51	7·00	41—31—8	5·97
,, ...	T 80	10·00	98—13—8	9·83
Pea	P. F. 1	2·68	30—8—8	11·27
,, ...	P. F. 2	3·38	34—20—0	10·20
,, ...	P. F. 3	4·17	29—19—0	7·07
,, ...	P. F. 4	1·07	10—15—8	9·72
Gram	T 58	4·58	30—7—0	6·58
,, ...	T 17	26·00	160—30—0	6·18
,, ...	T 25	5·00	34—16—12	6·88
,, ...	P. F. 3	1·27	14—26—0	11·53
Oats grain . . .	B. S. I	128·17	2,193—1—10	17·11
,, ...	B. S. II	10·17	176—14—8	17·34
,, hay . . .	B. S. I	91·50	5,288—33—0	57·80
Berseem—green fodder (Pusa Dhab area).	..	71·20	18,796—23—0	264·00
Ditto (New Area)	..	32·24	14,771—30—0	458·18

VI. EXPERIMENTAL WORK

The following experiments were conducted by the Agricultural Section during the year under report :—

1. *Manurial Experiments*—

(*a*) Permanent manurial and rotation experiments, Punjab field, Blocka C. & D.

(*b*) New manurial and rotation experiments in Randomised blocks conducted on the lines of the above experiment, Punjab field, Block A.

(*c*) Green-manuring experiments with sann-hemp, *guar*, (*Cyamopsis psoralioides*), *meth* (*Phaseolus aconitifolius*), Soybean cowpea and velvet-bean on wheat, Punjab field, Block B.

(*d*) Effects of sulphate of potash and muriate of potash on berseem seed production, Simri Dhab.

(*e*) Manurial experiments with rape-cake and superphosphate on sugarcane : different doses of nitrogen with a constant amount of phosphoric acid, Old Jhilli.

(*f*) Manurial experiments with superphosphate and rape-cake on sugarcane : different doses of phosphoric acid with a constant amount of nitrogen, Old Jhilli.

(*g*) Manurial experiments with sulphate of potash on sugarcane : different doses of potash with standard manure, Janghat field.

(*h*) Sugarcane manurial and rotation experiments, Harpur Jhilli.

(*i*) Manurial experiments with organic and inorganic fertilisers on sugarcane, New Area, Pusa A.

(*j*) Effect of farmyard manure and silt on the tonnage yield of sugarcane, New Area, Pusa B.

2. *Varietal yield trials*—

(*a*) Maize for fodder, Punjab field, Block B.

(*b*) Maize for corn, Punjab field, Block B.

(*c*) Soybean for fodder, Punjab field, Block B.

(*d*) Soybean for seed, Punjab field, Block D.

(*e*) Gram, Punjab field, Block B.

(*f*) Field-pea (*Pisum arvense*), Punjab field, Block B.

(*g*) Pea (*Pisum sativum*), Punjab field, Block B.

(*h*) Barley, North Pangarbi field.

(*i*) Oats, North Pangarbi field.

(*j*) Wheat, North Pangarbi field.

(*k*) Wheat, Brickfield No. II.

(*l*) Sugarcane, Co.'s 214, 299 and 313, Old Jhilli.

(*m*) Sugarcane, Co.'s 210, 213 and 331, Old Jhilli.

(*n*) Sugarcane, Co.'s 210 and 213, New Area, Pusa A.

3. *Experiments for other Sections of the Institute*—

(*a*) Manurial experiments with organic and inorganic fertilisers on sugarcane for the Imperial Agricultural Chemist, New Area, Pusa A.

(*b*) Green manuring experiments for the Bacteriologist : maize and wheat, sann-hemp and wheat, *urid* (*Phaseolus Mungo* var. *Roxburghii*) and wheat, sann-hemp tops and wheat, North Nepali field.

(*c*) Green-manuring experiments for the Bacteriologist : sann-hemp, sann-hemp tops, *urid* and soybean on wheat, Nepali field.

(*d*) Green-manuring experiments for the Bacteriologist : sann-hemp and Mexican sunflower on wheat, Nepali field.

(*e*) Experiments on the yellowing of sugarcane leaves for the Bacteriologist, New Area, Pusa A.

(*f*) Preliminary experiments with oats for yield trial with *rahar* for the Imperial Economic Botanist, Chandman paddock.

(*g*) Mosaic tonnage experiments with Co. 213 for the Imperial Mycologist : mosaic *versus* mosaic free cane, Silk House Area.

4. *Miscellaneous experiments*—

(*a*) Experiments to see the effect of speed of tractor-drawn implements on soil tilth and crop yield, Brickfield, No. II.

(*b*) Effect of formalin treatment on oats against smut, Brickfield, No. II.

(*c*) Spacing experiments with maize for fodder, Punjab field, Block B.

(*d*) Spacing experiments with maize for corn, Punjab field, Block B.

(*e*) Complex experiments with the cultivation of sugarcane : spacing and arrangement of setts at planting, New Area, Pusa B.

(*f*) Sugarcane cutting experiments with Co. 210 for ascertaining the correct size of experimental plots, New Area, Pusa A.

(*g*) Interlocking experiments with ' lodging ' sugarcane varieties, New Area, Pusa A.

(*h*) Trashing of early ripening canes for seed with Co.'s 214, 299, 281 and 313, Old Jhilli and Janghat fields.

(*i*) Germination study in trashed and fresh canes, New Area, Dholi block.

VII. RESULTS OF FIELD AND OTHER EXPERIMENTS

1. Manurial Experiments

(*i*) *Permanent manurial and rotation experiments.*—These experiments were continued as before.

The yields in various plots during the year were as follows :

Results of permanent manurial and rotation experiments for the year 1933-34.

Treatment	A SERIES		B SERIES		
	KHARIF 1933	RABI 1933-34	KHARIF 1933	RABI 1933-34	
	Maize grain per acre	Wheat grain per acre	Maize grain per acre	Peas grain per acre	Barley grain per acre
	lb.	lb.	lb.	lb.	lb.
GROUP I					
1. No manure (Check plot No. 1).	411	652	460	378	..
2. Farmyard manure @ 4,000 lb. per acre.	591	1,068	797	571	..
3. Farmyard manure @ 8,000 lb. per acre.	690	1,320	944	854	..
4. Farmyard manure @ 4,000 lb. per acre *plus* rape-cake to supply 20 lb. nitrogen per acre at the time of last interculture.	928	1,280	1,068	764	..
5. Rapecake @ 40 lb. nitrogen per acre, half to be applied just before *kharif* sowing and half to be applied at last interculture.	842	956	961	558	..
GROUP II					
6. Sulphate of ammonia @ 40 lb. nitrogen per acre, half before *kharif* and half before *rabi* sowing, but in the year when *rahar* is sown, it is to be applied in one dose in *kharif*.	460	516	468	312	..
7. Sulphate of potash @ 50 lb. K_2O per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* crop is sown, it is to be applied in one dose in *kharif*.	370	448	431	353	..
8. Superphosphate @ 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown, it is to be applied in one dose in *kharif*.	632	816	575	813	..

Treatment	A SERIES		B SERIES		
	KHARIF 1933	RABI 1933-34	KHARIF 1933	RABI 1933-34	
	Maize grain per acre	Wheat grain per acre	Maize grain per acre	Peas grain per acre	Barley grain per acre
	lb.	lb.	lb.	lb.	lb.
GROUP II—*contd.*					
9. Sulphate of potash @ 50 lb. K_2O per acre and superphosphate @ 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown, they are to be applied in one dose in *kharif*.	640	1,124	640	895	..
10. Sulphate of ammonia @ 40 lb. nitrogen, sulphate of potash @ 50 lb. K_2O and superphosphate @ 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown, they are to be applied in one dose in *kharif*.	673	984	682	755	..
11. Sulphate of ammonia @ 40 lb. nitrogen and superphosphate @ 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown, they are to be applied in one dose in *kharif*.	501	836	682	731	..
13. No manure (Check plot No. 2)	411	412	378	246	..
14. Sulphate of ammonia @ 40 lb. nitrogen per acre, sulphate of potash @ 50 lb. K_2O per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown, they are to be applied in one dose in *kharif*.	476	476	468	172	..
GROUP III					
12. Green manure in conjunction with a purely cereal rotation.	G.M.	552	G.M.	..	661
15. Effect of green manure and leguminous crop in the rotation.	G.M.	976	698	374	..
16. As for plot No. 15, but with an additional application of superphosphate @ 80 lb. P_2O_5 per acre to be applied with green manure only.	G.M.	2,060	1,047	1,076	..
17. No leguminous crop and no green manure.	550	716	468	..	361
18. No manure (Check plot No. 3) .	595	528	567	263	..

(*ii*) *The new manurial and rotation experiments*, full details of which have been given in the last year's report, were continued this year in the Punjab field, Block A. The following are the results of the experiments:—

Treatment per acre	Mean yield per plot	
	Maize No. 1 lb.	Pea No. 1 lb.
A. No manure	4·127	12·250
B. Farmyard manure* @ 8,000 lb.	6·871	21·500
C. Rape-cake @ 40 lb. N	14·050	18·125
D. Amm. sulphate @ 40 lb. N	5·695	11·475
E. Potassium sulphate @ 50 lb. K_2O	4·583	13·375
F. Superphosphate @ 80 lb. P_2O_5	4·521	21·025
G. Pot. sulphate @ 50 lb. K_2O & superphosphate @ 80 lb. P_2O_5.	3·302	20·475
H. Amm. sulphate @ 40 lb. N, superphosphate @ 80 lb. P_2O_5 & Pot. sulphate @ 50 lb. K_2O	6·396	18·075
I. Amm. sulphate @ 40 lb. N and superphosphate @ 80 lb. P_2O_5	7·858	20·500
J. Amm. sulphate @ 40 lb. N and pot. s lphate 50 lb. K_2O	5·833	10·875

*Composition of farmyard manure :—N—0. 64% ; P_2O_5—0·40 %; K_2O—0·78%

Fisher's ' z ' test was applied and the general effect of treatments was found to be significant at the one per cent. level. Fisher's ' t ' test was also applied and the results were significant as shown below:

Maize

Critical difference = 2·669 (P=·01)
" " = 2·013 (P=·05)
C>I=B=H>J=D=E=F=A=G

Pea

Critical difference = 5·819 (P=·01)
" " = 4·390 (P=·05)
B=F=I=G=C=H>A=D=E=J

(*iii*) *Green manuring experiments in the Punjab field, Block B.*— The experiment was started this year with a view to study the effect

of various leguminous crops as green manure on the yields of wheat grown in *rabi*. The six treatments were put in a 6×6 Latin Square and the following results were obtained :—

Treatment	Mean yield per plot in lb. of wheat P. 52 (Area of each plot = 0·03 acre)	'z' test	Critical difference
T 1—Sann-hemp . . .	36·46	Not significant	
T 2—Cowpea	38·00		7·856 (P = ·05)
T 3—*Guar*	36·25		
T 4—*Meth*	34·71		
T 5—Soybean	28·58		
T 6—Velvetbean . . .	36·50		

Conclusions :—T1 =T2 = T6 > T5

(*iv*) *Effect of sulphate of potash and muriate of potash on berseem seed production.*—The object with which this experiment was started last year was not attained during the year under report. Besides the usual manuring programme, detailed in last year's report, the crop was also put on high land without any treatment and grown under controlled irrigation. This method of growing the crop for seed has shown some success, and it is expected that better results will be obtained next year with further control of irrigation.

(*v*) *Manurial Experiments with Rape-cake and superphosphate on sugarcane Co. 213 in Old Jhilli.*—The experiments were laid out in Randomised Blocks with six replications for each treatment. The manures were applied at the time of planting sugarcane, and the amount of phosphoric acid in rape-cake was deducted from the main dressing of superphosphate.

The results may be summarized as follows :—

Treatment per acre	Sucrose per cent. (Feb.)	Tonnage		
		Mean yield per plot in lb. (Area of each plot = 0·05 ac.)	"z" test	"t" test
T 1—No manure . .	15·94	3650·00	Not significant	Not significant
T 2—40 lb. N + 50 lb. P_2O_5	14·95	3922·00		
T 3—60 lb. N + 50 lb. P_2O_5	14·49	3927·00		
T 4—80 lb. N + 50 lb. P_2O_5	15·69	3825·25		

Treatment per acre	Sucrose per cent. (March)	Mean yield per plot in lb. (Area of each plot=0·05 acre)	"z" test	Critical difference
T 1—No manure . .	17·56	2760·4	Significant at the 1% level	432·83 (P=·01)
T 2—50 lb. P_2O_5+40 lb. N	16·64	3282·0		
T 3—75 lb. P_2O_5 + 40 lb. N	16·31	3348·7		
T 4—100 lb. P_2O_5 + 40 lb. N	16·36	3305·4		

Conclusions :—T2=T3=T4>T1

(*vi*) *Sugarcane manurial and rotation experiments with Co. 210 in Harpur Jhilli.*—The object of this experiment is to maintain the land in best possible condition for a close cane rotation such as cane-fallow—cane. The treatments were put in double Latin Squares with ten replications for each. The experimental area was under cane during 1931-32. The treatments per acre were :—

A. Fallow in *kharif* and 14 tons farmyard manure (Dowlatpore dressing) at the end of monsoon.

B. Fallow in *kharif* and complete minerals (40 lb. N as ammonium sulphate, 50 lb. P_2O_5 as superphosphate and 40 lb. K_2O as potassium sulphate) applied at the time of planting cane.

C. Sann-hemp sown in *kharif* and ploughed in after eight weeks with 50 lb. P_2O_5 as superphosphate. 40 lb. N as rape-cake applied at the time of planting cane.

D. Sann-hemp sown in *kharif* and ploughed in after eight weeks. Complete minerals (as in treatment B) applied at the time of planting cane.

E. Fallow in *kharif* and standard manure (40 lb. N as rape-cake and 50 lb. P_2O_5 as superphosphate) applied at the time of planting cane.

The results of the experiment are given below :—

Treatment	Sucrose per cent. (Feb.)	Tonnage: Mean yield per plot in lb. (Area of each plot = 0·045 acre)	"z" test	Critical difference
A	14·70 14·05	3185·7	Significant at the 1% level	171·36 (P=·01)
B	15·63 15·91	2698·7		127·02 (P=·05)
C	14·98 15·19	2847·4		
D	15·35 15·70	2737·7		
E	15·18 15·35	2695·3		

Conclusions :—A>C>B=D=E

The experiment will be repeated in 1935-36.

(*vii*) *Manurial experiments with organic and inorganic fertilisers on sugarcane Co. 210 in the New Area, Pusa A.*—The experiment was laid out in Latin Square with six replications for each treatment. The different kinds of manures applied per acre were as follows :—

T1—No manure.

T2—10 tons farmyard manure applied at the end of monsoon.

T3—20 tons farmyard manure applied at the end of monsoon.

T4—Green manure (sann-hemp) in *kharif* and complete minerals (40 lb. N as amm. sulphate, 40 lb. K_2O as pot. sulphate and 50 lb. P_2O_5 as superphosphate) applied at the time of planting cane.

T5—Complete minerals (as in T4) applied at the time of planting cane.

T6—Green manure (sann-hemp) in *kharif* with 50 lb. P_2O_5 as superphosphate.

It will be seen in the table given below that the dressing of 20 tons farmyard manure per acre has turned out to be the best, and this has further been confirmed by the results of the manurial experiment of Harpur Jhilli detailed before. The results of these two experiments indicate that farmyard manure (at the rate of 14 tons per acre) is the most suitable dressing for sugarcane crop in this tract.

Treatment	Sucrose per cent. (Decr.)	Tonnage		
		Mean yield per plot in lb. (Area of each plot = 0·022 acre)	"z" test	Critical difference
T1	15·47	724·0	Significant at the 1% level	219·32 (P = ·01)
T2	14·89	1300·7		
T3	13·65	1667·2		
T4	14·59	1413·5		160·81 (P = ·05)
T5	15·13	1110·2		
T6	15·15	1145·2		

Conclusions :—T3 > T1, T2, T4, T5 & T6 ; T4 > T1, T5 & T6 ; T2 > T1 & T5 ; T6 > T1 ; T5 > T1

(*viii*) *Effect of farmyard manure and silt on the tonnage yields of sugarcane Co.'s 210, 303, 313 and 331.*—A preliminary experiment as

to the possibility of replacing farmyard manure, which at times cannot be had in large quantities, by some equally good and easily procurable substitute, such as river silt, was carried out in the New Area, Pusa B.

The results of the chemical analysis of silt and that of the experiment are given below :—

CHEMICAL ANALYSIS OF SILT

Organic nitrogen—0·036% on air dry soil.

Phosphoric acid (P_2O_5)—0·048% on air dry soil.

Potash (K_2O)—0·921 % on air dry soil.

The silt was poor, both in organic nitrogen and phosphoric acid.

Tonnage yield per acre

Treatment	Co. 210	Co. 303	Co. 313	Co. 331
	Mds.	Mds.	Mds.	Mds.
Silt @ 766 Mds. per acre . .	649·15	660·97	650·96	866·54
Farmyard manure @ 367 Mds. per acre	614·66	786·48	568·05	1036·40

2. VARIETAL YIELD TRIALS

(*i*) *Yield trial with maize for fodder in the Punjab field, Block B.*— Four different varieties of maize were tried in double Latin squares with eight replications. The results of the experiment are summarized below :—

Variety	Mean yield per plot in lb. (Area of each plot=0·016 acre)	" z " test	Critical difference
P. F. 1	231·13	Significant at 5%level	33·537 (P = ·01)
P. F. 2	226·63		24·250 (P = ·05)
P. F. 3	221·13		
Local	194·75		

Conclusions :—PF1=PF2=PF3> Local

(*ii*) *Yield trial with maize for corn in the Punjab field, Block B.*—The layout of the experiment was a double Latin square with eight replications for each variety. It will be seen from the results given below that the differences between the varieties are not statistically significant.

Variety	Mean yield per plot in lb. (Area of each plot = 0·016 acre)	'z' test	't' test
P. F. 1	12·74	Not significant	Not significant
P. F. 2	11·44		
P. F. 3	13·53		
Local	12·13		

(*iii*) *Yield trial with Soybean for fodder and seed in the Punjab field, Blocks B & D.*—Three varieties of soybean, evolved in the Agricultural Section were tried in a set of four Latin Squares for fodder and seed separately.

The results are given below :—

Variety	Mean yield per plot in lb. (Area of each plot = 0·019 acre)	'z' test	Critical difference
Fodder—			
No. 1—Yellow	227·3	Significant at the 1% level	18·28 (P = ·01)
No. 2—Chocolate	264·5		
No. 3—Black	196·2		
	(Area of each plot 0·015 acre)		
Seed—			
No. 1—Yellow	19·71	Significant at the 1% level	2·523 (P = ·01)
No. 2—Chocolate	18·92		
No. 3—Black	15·20		

Conclusions :—Fodder No. 2 > No. 1 > No. 3

Seed No. 1 = No. 2 > No. 3

(*iv*) *Yield trial with gram in the Punjab field, Block B.*—The second year's trial with gram varieties was carried on during the year under report and below are the results :—

Variety	Mean yield per plot in lb. (Area of each plot = 0·022 acre)	'z' test	Critical difference
T. 17	11·72	Significant at the 1 % level	7·106 (P = ·01)
T. 25	13·53		
T. 28	12·81		
T. 58	15·19		
P. F. 3	14·75		
P. F. 6	11·38		
P. F. 11	23·09		
P. F. 17	13·53		

Conclusions :—PF11 > T17 = T25 = T28 = T58 – PF3 = PF6 = PF17

(*v*) *Yield trial with field-pea* (*Pisum arvense*) *in the Punjab field, Block B.*—The experiment was laid out in a set of four Latin Squares with twelve replications for each variety. The results are shown below :—

Variety	Mean yield per plot in lb. (Area of each plot = 0·008 acre)	'z' test	Critical difference
P. F. 6	3·996	Significant at the 1 % level	0·905 (P = ·05)
P. F. 7	3·505		
P. F. 8	4·563		

Conclusions :—P F 8 > P F 7

(*vi*) *Yield trial with pea* (*Pisum sativum*) *in the Punjab field, Block B.*—The trial was conducted in double Latin Squares with

eight replications for each variety. The following are the results of the experiments :—

Variety	Mean yield per plot in lb. (Area of each plot = 0·022 acre)	'z' test	Critical difference
P. F. 1 . . .	12·25	Not significant	4·481 (P = ·05)
P. F. 2 . . .	15·69		
P. F. 3 . . .	17·63		
P. F. 4 . . .	14·00		

Conclusions :—P. F. 3>P. F. 1.

(vii) Yield trials with oats, barley and wheat in North Pangarbi field.—Each of these crops was tried separately in double Latin Squares with eight replications. The results are summarized below :—

Variety	Mean yield per plot in lb. (Area of each plot = 0·009 acre)	'z' test	Critical difference
Oats B. S. 1 . .	17·72	Significant at the 1 % level	1·980 (P = ·01)
„ B. S. 2 . .	17·56		1·432 (P = ·05)
„ Hybrid C .	13·66		
„ „ J .	15·78 (Area of each plot=0·008 acre)		
Barley T. 21 . .	15·13	Do.	3·044 (P =·01)
„ C. 251 .	11·44		
„ Local 1 .	10·91		
„ „ 2 .	11·34		
Wheat P. 4. . .	5·06	Do.	1·205 (P = ·01)
„ P. 12 . .	3·94		0·872 (P = ·05)
„ P. 52 . .	9·72		
„ Country .	5·50		

Conclusions :—

Oats B. S. 1=B. S. 2>H. J.>H. C

Barley T. 21 C. 251=Local 1=Local 2

Wheat P. 52> Country=P. 4>P. 12

(*viii*) *Yield trial with wheat in Brickfield No. 2 : P. 52 versus Country.*—The experiment, on its third year of trial during the year under report, was concluded with the following results. The trial was carried out in Beaven's half-drill-strip method with twelve replications :

	lb.
Mean difference in favour of P. 52	9·67
Standard error	1·37
Critical difference (P = ·01)	4·25

The result is highly significant at the one per cent level.

3. Miscellaneous Experiments

(*i*) *Experiments to see the effect of speed of tractor-drawn implements on soil tilth and crop yield in Brickfield No. 2.*—The second year's experiment was conducted on the lines detailed in the last year's report. The following implements were used in the two treatments :—

A.—Ploughing with five-furrow " Vice-Consul Share plough " at 4·5 inches on first speed (at 2·5 miles per hour) and harrowing twice with " Roderic Lean Disc Harrow " at the same speed.

B.—Ploughing with three-furrow " Consul Plough " at 4·5 inches on third speed (at five miles per hour) and harrowing twice with " Roderic Lean Disc Harrow " at the same speed.

The " Vickers " tractor, 23/40 H. P. was used for the work.

The tilth of soil in the two treatments was like the previous year's experiment. Oats B. S. 1 was grown in *rabi* and the results given below confirm the conclusions reached before :—

	lb.
Mean difference in favour of 5 miles speed	2·75
Standard error	5·48
Critical difference (P = ·05)	12·64

(*ii*) *Effect of formalin treatment against smut in oats.*—An experiment was laid out on field-scale (Brickfield No. 2) to test the effectiveness of formalin treatment by dry method on oats infested with smut. The seeds were treated before sowing and were put against untreated seed in Beaven's half-drill-strip method with twelve replications. The ultimate size of plot was 117 ft. × 14 ft. The results based on the final yields of oats grain were significant in favour of the treatment as shown below :—

	lb.
Mean difference in favour of formalin treatment	3·56
Standard error	1·24
Critical difference (P = ·05)	2·74

(*iii*) *Spacing experiments with maize P. F. 1 for fodder and corn in the Punjab field, Block B.*—The experiments were laid out in double Latin Squares with eight replications for fodder and corn separately. The details of spacing and the results are given below :—

Spacing	Mean yield per plot in lb. (Area of each plot =0·016 acre)	'z' test	't' test
For Fodder			
T. 1—9 inches . .	232·63	Significant at 1 per cent. level	Critical difference 48·395 (P=·01) 34·995 (P=·05)
T. 2—12 „ . .	180·63		
T. 3—15 „ . .	189·75		
T. 4—18 „ . .	168·50		T. 1 > T. 2 = T. 3=T. 4
For Corn			
T. 1—9 inches . .	12·44	Not significant	Not significant
T. 2—12 „ . .	11·95		
T. 3—15 „ . .	11·77		
T. 4—18 „ . .	11·77		

(*iv*) *Complex experiments with cultivation of sugarcane Co. 210 in the New Area, Pusa B.*—The two variables in the experiment were (*i*) spacing : 3 ft. and 2½ ft. between rows and (*ii*) arrangement of setts at planting : eye to eye and end to end. The experiment was laid out in Randomised Blocks with six replications for each of the following treatments :

T. 1—2½ ft. spacing between rows, setts planted end to end.
T. 2—2½ ft. spacing between rows, setts planted eye to eye.
T. 3—3 ft. spacing between rows, setts planted end to end.
T. 4—3 ft. spacing between rows, setts planted eye to eye.

The statistical results of the experiment are given below :—

Treatment	Average tonnage yield per acre in lb.	'z' test	't' test
3 ft. spacing . .	63957·5	Not significant	Not significant
2½ ft. „ . .	66945·0		
End to end . . .	65519·0	Not significant	Not significant
Eye to eye . . .	65353·5		

(*v*) *Sugarcane cutting experiments with Co. 210 for ascertaining the correct size of experimental plot in the New Area, Pusa A.*—As most of the sugarcane experiments on the Farm are now laid down under Co. 213 or Co. 210, it was thought advisable to check the results obtained last year from the cutting experiments of Co. 213 conducted at Meghaul (Monghyr district) by a similar experiment with the other variety at Pusa. An area of four acres was put under Co. 210 and cut into 1/242 acre plots, each consisting of a single row of 3 ft. wide and 60 ft. in length. The data obtained from this experiment are being analysed statistically.

(*vi*) *Interlocking experiments with 'lodging' sugarcane varieties in the New Area, Pusa A.*—Co. 303 and Co. 322, the two 'lodging' varieties were grown interlocked with Co. 213 for testing their tonnage yields against Co.'s 213 and 331 in Randomised Blocks with six replications. The results of the experiment are given in the table below :—

Variety	Mean yield per plot in lb. (Area of each plot = 0·05 acre)	'z' test	Critical difference
A—Co. 213 + Co. 303.	2730·25	Significant at the 1 per cent. level	469·01 (P = ·05) 648·61 (P = ·01)
B—Co. 213 + Co. 322 .	1946·92		
C—Co. 213 . .	2382·00		
D—Co. 331 . .	3320·83		

Conclusions :—D > A, B & C ; A > B

(*vii*) *Trashing of early ripening canes for seed with Co's. 214, 299, 281 and 313 in Old Jhilli and Janghat fields.*—The experiment was continued during the year under report and the damage caused by jackals and pigs to the standing crop was found to be less in comparison with the previous years' loss.

In germination study made on trashed and fresh canes under field conditions, it was found that percentage of germination was more in the case of trashed seed in all the varieties except Co. 299, where fresh seed gave better results.

An article dealing with the results of the above experiments will be published separately.

VIII. SUGARCANE VARIETAL WORK

The earthquake on January 15th caused a complete dislocation of mill work in the neighbourhood and in consequence it was only possible to put through one mill trial in the season, that on the early variety Co. 299, details of which have been published separately.

The impending trials of Co. 281 as a semi-irrigated cane in place of Co. 213 and Co. 331 as a heavy tonnage late ripening cane for April crushing had to be postponed indefinitely. A large quantity of cane cut out from experiments which required harvesting in February and March could not be disposed of, but every opportunity was taken to supply as much cane seed as possible to all concerns where railway facilities were still operative. As a result, it was possible to clear off a very large percentage of the early canes. The general tonnage canes were held over until the Samastipur mill re-opened on the 30th April when they were all taken off. This delay has given us an excellent opportunity of observing on a large scale the behaviour of cane allowed to stand over into May. It was noticeable that on heavy land and land in a four-year rotation, the cane stayed green into May despite the intense dry weather and absence of any hot weather rain. On three-year rotation land, how-the cane dried up very quickly, as the analyses clearly show.

The following varieties of cane were planted on a field scale during 1933-34 :—

Coimbatore canes : 210, 213, 214, 281, 285, 299, 303, 304, 313, 322, 331, 337, 339, 343 and 344.

The following varieties were under multiplication in the Nursery at New Area :

(*a*) Varieties imported from Coimbatore in 1931—Coimbatore canes : 347, 348, 350, Tuc. 393 and Tuc. 472 (Co. 338 was under observation in Sericulture area).

(*b*) Varieties imported from Coimbatore in 1932—Coimbatore canes : 381, 382, 384, 386, 387, 388, 393, 395, 396 and 397.

(*c*) Varieties imported from Coimbatore in 1933—Coimbatore canes : 360, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381*, 382*, 383, 384*, 385, 386*, 387*, 388*, 389, 390, 391, 392, 393*, 394, 395*, 396*, 397*, 402, 408, 412, 413, 417 and 419.

The following varieties were rejected for 1934-35 planting—Coimbatore canes : 304, 322, 338, 350, Tuc. 393 and Tuc. 472.

All the above varieties were marked for rejection in 1933-34, but were finally rejected for 1934-35 planting.

Co. 322 lodges badly and can only be considered for estate planting, if interlocked with some other variety which has a good stand.

* Repeats.

Co. 338, Co. 350, Tuc. 393 and Tuc. 472 were discarded on account of bad agricultural habit.

Co. 338 was carefully observed to ascertain its value as an early cane, but its sucrose proved to be far below the early standard cane in October, and it was finally rejected.

Co. 388—10·73
Co. 299—12·41
} Sucrose in October.

Co. 304 proved to be below Co. 210 in tonnage and sucrose content and to have a higher fibre percentage.

Coimbatore canes : 367, 372, 376, 379, 380, 383, 385, 389, 390, 392 and 402. All failed completely in the first season's planting in the nursery. They will be repeated in 1935.

The following varieties were planted during February, 1934.

(*i*) Field scale trial against standard canes, Coimbatore canes : 210, 213, 214, 281*, 299, 303, 313, 331, 337, 339, 343, 344, 387, 388, 393, 395, 396 and 397.

(*ii*) Small scale trial under multiplication in nursery :

(*a*) 1931 Importations—Coimbatore canes : 347 and 348,

(*b*) 1932 Importations—Coimbatore canes : 381, 382, 384, and 386.

(*c*) 1933 Importations—Coimbatore canes : 360, 366, 368, 369, 370, 371, 373, 374, 375, 377, 378, 381, 382, 384, 386, 391, 394, 408, 412, 413, 417 and 419.

(*d*) 1934 Importations—Coimbatore canes : 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515 and 516.

The long list of importations show clearly that the problem of replacing our standard canes is still to seek. The majority of the canes received and tested do not show any improvement of that dual purpose nature which is essential, if a cane is to be welcomed to both grower and mill. Improvements in sucrose bringing in their train lower tonnage can never succeed in replacing a cane of Co. 213 class in a tract where tonnage alone is paid for, and the grower is free. The majority of the canes showing any promise ultimately fail on this point. Improvements on the tonnage side, such as Co. 285 find the mills adamant.

I do not consider that any marked improvement will ever be possible until the basis of value is radically revised. Till then the mill doing 9·5 on standard cane, and the grower being paid for the tonnage in Co. 213 will both feel they have the best deal possible.

Co. 213 and Co. 210 represent the nearest possible approach, in my opinion, to satisfying mill and grower. The monsoon variations and the hot weather period are such important factors in

* Semi-irrigated.

judging the real value of a cane, that it is impossible to justify the theory of taking any chance of replacing the above canes, which have made the industry, until absolute certainty exists, as to the value of the change. A change for the sake of a change is absurd and cannot be too strongly deprecated, and this should be carefully noted.

Results of field experiments and mill trial conducted with different varieties of sugarcane.

(*i*) *Mill trial of Co. 299.*—This cane was tested in a mill trial against Co. 214 and Co. 313 at the Samastipur Central Sugar Factory on the 19th November, 1933, by kind permission of Messrs. Begg, Sutherland & Co. Co. 214 which has been the standard early ripening cane to-date in the tract has a bad agricultural habit and poor tonnage yields. Recent trials conducted in the Agricultural Section had clearly proved Co. 299 to be an early cane of the class required for the district ; its tonnage yields and laboratory analysis pointed to its being superior to Co. 214, the cane it was desired to replace. For the mill trial, an area of 1·64 acres was laid down in Randomised Blocks in Old Jhilli with six replications for each variety. The mill trial results have shown that a definite saving in raw material cost can be effected by the substitution of Co. 299 for Co. 214. The details of the results have been published separately.

(*ii*) *Tonnage yield trial with sugarcanes Co. 210, Co. 213 and Co. 331 in Old Jhilli.*—The varieties were put in Randomised Blocks with six replications for each. The results are tabulated below :—

Variety	Mean yield per plot in lb. (Area of each plot = 0·05 acre)	'z' test	Critical difference
Co. 210 . . .	2995·33	Significant at the 1 per cent. level	501·68 (P=·01)
Co. 213 . . .	2889·75		
Co. 331 . . .	3815·00		

Conclusions :--Co. 331 > Co. 210=Co. 213

(*iii*) *Tonnage yield trial with sugarcanes Co. 210 and Co. 213 in the New Area, Pusa A.*—The experiment was laid out in Beaven's

half-drill-strip method with twelve replications for each variety. It will be seen that the result is not statistically significant.

	lb.
Mean difference in favour of Co.213	205·38
Standard error	126·75
Critical difference (P = ·05)	276·19

It is important to notice that this experiment which has now been continued for some four years continues to give results which are not significant over a period of years. Co. 213 and Co. 210 are the standard canes of the tract and their selection for different areas must always be a question of local conditions, as it is impossible in face of the above figures, to give any definite ruling as to the tonnage superiority of one over the other.

Chemical analyses results and tonnage yields of principal varieties of sugarcane grown on the Pusa Farm during 1933-34.

Sugarcane variety	Field.	Sucrose per cent. in juice								Area in acres	Average Tonnage yield per acre (Mds.)
		Octr. 1933	Novr. 1933	Decr. 1933	Jany. 1934	Feby. 1934	March 1934	April 1934	May 1934		
Co. 210	H. Jhilli	..	..	..	..	..	..	..	..	4·17	699
	New Area	..	14·48	15·47	..	15·45	..	..	..	9·88	719
	Old Jhilli	..	..	..	..	..	15·60	..	..	·30	728
Co. 213	Old Jhilli	..	..	..	..	..	17·56	..	..	5·68	720
	Janghat	..	..	11·56	13·38	..	17·43	18·05	18·35	·38	700
	New Area	..	13·65	15·26	..	16·89	..	..	..	3·61	828
Co. 214	Old Jhilli	..	15·99	18·23	18·36	19·62	..	..	..	·30	570
	New Area	12·30	13·28	17·56	17·08	19·10	..	..	..	1·00	449
		15·19	16·61								
Co. 281	Janghat	10·07	13·29	16·74	17·56	17·89	19·88	18·67	18·16	11·44	763
Co. 285	New Area	..	..	..	..	..	..	..	..	1·70	856
Co. 299	Old Jhilli	..	16·04	16·63	17·59	18·26	..	..	..	·30	604
				17·70							
	New Area	12·79	15·69	16·48	18·02	18·86	..	..	..	1·52	460
		14·40	16·30								
Co. 303	New Area	..	14·08	15·53	..	17·94	..	..	..	1·24	304
Co. 313	Old Jhilli	..	14·96	17·54	17·43	18·36	..	..	..	·30	780
	Janghat									·33	700
	New Area	11·43	13·47	17·11	17·44	18·51	..	..	..	1·68	615
		12·29	14·06								

Co. 331 . .	Old Jhilli	..	..	..	..	..	..	..	..	1·30	983
	New Area	..	14·34	14·20	..	15·67	..	..	..	1·60	956
	Janghat	..	11·36	..	13·95	..	18·13	18·94	19·34	2·00	1,139
Co. 337 . .	Old Jhilli	..	..	..	..	..	..	..	..	·06	400
	New Area	13·55	16·17	17·19	17·72	18·09	..	..	..	·04	642
Co. 339 . .	New Area	..	15·20	17·45	18·04	18·79	..	..	..	·04	378
Co. 343 . .	,, ...	..	13·24	15·31	16·79	16·39	..	..	..	·06	969
Co. 344 . .	,, ...	..	14·40	15·20	17·57	17·73	..	..	..	·08	774

IX. MISCELLANEOUS CROPS GROWN FOR THE SECTIONAL OFFICERS OF THE INSTITUTE

(1) The following improved varieties of crops were grown for the Imperial Economic Botanist in the Agricultural Section for seed multiplication. The average yield per acre of each variety is given below :—

Crop	Field	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
Gram T 17	Gonhri	4·00	2972·00	743·00
„ T 25	„	5·00	2832·10	566·42
„ T 58	„	4·00	2236·10	559·03
Linseed T 124	Old Jhilli	1·50	501·90	334·60
„ H 10	„	0·50	96·70	193·40
„ H 55	„	0·50	67·90	135·80
„ H 21	„	0·50	105·90	211·80
„ H 68	„	0·50	52·40	104·80
„ T 12	„	1·20	454·60	378·83
„ T 121	„	1·00	323·00	323·00
Russian Flax	„	0·30	37·00	123·33
Lentil T 54	„	1·00	664·50	664·50
„ T III-86	„	1·00	695·30	695·30
Oats Hybrid C	„	2·50	3072·80	1229·12
„ „ J	„	2·50	3966·20	1586·48
„ B. S. II	„	1·50	2127·10	1418·07
Wheat P 12	Mysore	9·75	11157·70	1144·38
„ P 52	„	9·75	13850·70	1420·58
„ P 4	S. Pangarbi	11·00	5827·30	529·75
„ P 111	Nepali	11·18	10072·60	900·95
„ P 101	„	4·50	4260·40	946·75
Barley T 21	B. F. I(30 ac. block)	10·00	11898·60	1189·86
Arhar T 24	H. Jhilli (do.)	10·00	6697·50	669·75
„ T 51	„ „	10·00	3438·50	343·85
„ T 15	Chheonia	5·00	3676·10	735·22
„ T 80	„	6·75	3761·00	557·19

(2) The following crops were grown in small plots for the Imperial Entomologist during the year under report :

Kharif—

Maize, *juar* (*Andropogon Sorghum*), *bajra* (*Pennisetum typhoideum*), *urid* (*Phaseolus Mungovar. Roxburghii*), *mung* (*Phaseolus radiatus*), castor, *til* (*Sesamum indicum*), sann-hemp, sweet potato, Java indigo, turmeric, ginger and sugarcane : Co. 213 and Co. 285 (October, 1932) ; Co. 213 (February, 1933) ; Co. 213 and Co. 285 (October, 1933) ; Co. 210, Co. 213, Co. 214 and Co. 313 (February, 1934).

Rabi—

Wheat, barley, peas, gram, mustard, linseed, lentil, chillies tobacco, potato and safflower.

X. MACHINERY

1. Steam ploughing tackle and tractors

The majority of the area outside the small field experiments was dealt with by tractors in the year under report. The steam tackle being only on the land for opening out at the end of the monsoon.

The collection of working data and cost figures for all the tractors under test was continued.

The International McCormick Deering 15/30 H. P. purchased in 1927 completed its seventh year and worked for 446·83 hours including belt work. It cost Rs. 1,191-6-9 in spare parts as against Rs. 453-15-5 expended last year. It is, therefore, now evident that it has worked to the economic limit, but further figures must be obtained to ascertain the time at which the breakdown period is reached.

It will be noticed that the cost of ploughing owing to the cost of the above spare parts went up to Rs. 5-15-1 per acre as against Rs. 4-13-5 per acre last year—a rise of approximately 23 per cent. on the major operation, and the curve may be expected to steepen rapidly from now onwards.

There was not, however, a marked increase in fuel consumption. The rise in the quantity of kerosene oil used being 2·69 gallons per hour against 2·56 gallons last year. It must, however, be clearly realised that this close economy in fuel consumption in an old tractor can only be obtained by a very drastic replacement policy in engine parts which, it is possible, may prove more costly in the end, but such information is necessary to complete the investigation.

The Vickers 23/40 H. P. kerosine oil tractor worked for its fifth year. It was sparingly used owing to its exceptionally high consumption of kerosine oil. This tractor is clearly demonstrating the fact that high horse power in this class of tractor produces a very steep rise in fuel consumption at an early stage which it is almost impossible to control under normal conditions. It was chiefly employed for exceptionally heavy or fast work.

Crude-oil tractors.—This branch of tractor working, which up to a short time ago, represented a complete innovation, is now of the greatest value, as the complete change over which has taken place among manufacturing firms recently has brought the crude-oil tractor to the forefront in the place of the kerosine oil models.

We are now furnished with invaluable working data for four years as a result of our forward policy with this class of tractor.

The Lanz Bulldog 15/30 H. P. tractor, which is of the semi-Diesel type worked steadily for 437·04 hours. This model has no cylinder liner, and owing to the fact that duplicate air cleaners were not standard at the beginning, the cylinder was badly worn by dust. A complete new cylinder and piston had therefore to be fitted, and this, worked with duplicate air cleaners, is now giving perfectly satisfactory service, but the installation of a cylinder liner in this model is essential, as the saving in the above case would have been very marked had it been possible to rectify the trouble by merely fitting a new liner.

The total cost of spare parts was Rs. 999-12-3 (including Rs. 755 for new cylinder) as against Rs. 231-13-5 last year. It may, however, be taken for granted that future replacements will follow a normal curve. The cost of ploughing per acre was Rs. 4-10-4 as against Rs. 3-1-5 last year, but the crude-oil consumption was only 1·5 gallons as against 1·59 gallons in the previous year.

The Marshall semi-Diesel 15/30 H. P. tractor which was purchased in 1932 began to give considerable trouble after the first year's working due to the fuel pump cam slipping on sleeve and thereby making injection late. As this system has been entirely remodelled by the makers, the tractor was exchanged for the new 18/30 H. P. model on which the cam and sleeve are solid. This tractor is now working satisfactorily.

Changes of this class may be anticipated in the crude-oil tractor, as the design is by no means yet standardised and radical improvements may be looked for from year to year. This class of tractor has not been evolved like its kerosine oil prototype as a result of years of experiment and trial in motor car engines and has to obtain its data and improvements from field work. This point will come into greater prominence when the high speed vertical Diesels are in general use and many radical changes in design may be expected in course of time.

A distinct tendency to put a heavier tractor on the land is in evidence, partly because it enables the major work, ploughing to be done to greater depths and also because the H. P. capital cost is lessened, while the lengthening of service life is a further consideration, as the less liable a tractor is to overload, the longer will be its effective and economic life. Pneumatic treads are also coming in, and their effect on land is also in favour of the heavier types of tractor. In short the nearer the tractor can now approach to the steam engine in general, the better machine will it be for agricultural purposes.

A 9/18 H. P. " Farmall " row crop tractor was added to the test fleet in the year under report. This tractor embodies a completely

new principle in which the ploughing capacity is subordinated in design and construction to row crop work, *i.e.*, it is a tractor which can do row crop work and can also plough (while a tractor which is primarily constructed to plough cannot do row crop work at all). This, in all parts where the cost of labour is high, is a great advantage. This tractor is designed to intercultivate and ridge up, being of special construction with a very small turning radius, and all the implements working within or under the wheel spread. It will also plough two furrows and looks to be an exceptionally efficient design.

Statements showing the output, consumption and cost of cultivation by tractors for the year 1933-34

Statement No. 1

Summary of the work done

Name of tractor	Working hours	Ploughing		Disc-harrowing		Grubbing		Rolling		Drilling	
		Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres
Lanz Bulldog semi-Diesel 15/30 H. P.	437·04	279·52	235·22	28·08	47·50	117·19	228·51	10·25	32·25	2·00	5·00
McCormick Deering 15/30 H. P. K. Oil	356·92	107·16	109·08	137·26	256·82	92·50	205·95	12·16	37·25	7·83	17·00
Vickers 23/40 H. P. K. Oil	163·97	36·58	51·00	67·82	158·20	5·25	12·50	2·75	9·50	51·57	164·30

Statement No. 2

Acreage per hour

Name of tractor	Working hours	Ploughing	Disc-harrowing	Grubbing	Rolling	Drilling
Lanz Bulldog semi-Diesel 15/30 H. P.	437·04	0·84	1·69	1·95	3·15	2·50
McCormick Deering 15/30 H. P. K. Oil	356·92	1·01	1·87	2·22	3·06	2·17
Vickers 23/40 H. P. K. Oil	163·97	1·39	2·33	2·38	3·45	3·18

Statement No. 3

Fuel Consumption

Name of tractor	Working hours	K. Oil		Crude Oil		Petrol		Engine and gear Oil		Grease		Waste	
		Total galls.	Per hour galls.	Total galls.	Per hour galls.	Total galls.	Per hour galls.	Total galls.	Per hour galls.	Total lb.	Per hour lb.	Total lb.	Per hour lb.
Lanz Bulldog semi-Diesel 15/30 H. P.	437·04	20·54	0·05	657·53	1·50	..	..	76·78	0·18	76·00	0·17	38·00	0·09
McCormick Deering 15/30 H. P. K. Oil.	356·92	962·20	2·69	..	..	22·00	0·06	88·68	0·24	70·05	0·19	34·00	0·09
Vickers 23/40 H. P. K. Oil	163·97	554·55	3·38	..	..	11·00	0·06	44·57	0·27	30·00	0·18	17·37	0·11

Statement No. 4

Analysis of total cost

Name of tractor	Kerosine oil	Crude oil	Petrol	Lubricants and waste	Wages of mistris and water carriers	Wages of repairing staff	Spare parts	Total	Expenses per hour
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Lanz Bulldog semi-Diesel 15/30 H. P	15 6 10	287 10 3	..	207 1 4	62 8 9	135 6 0	999 12 3	1,707 13 5	3 14 6
McCormick Deering 15/30 H. P. K. Oil	721 10 3	..	35 12 0	197 7 11	75 13 2	175 2 3	952 4 3	2,158 1 9	6 0 9
Vickers 23/40 H. P. K. Oil	415 14 5	..	17 14 0	113 11 8	29 13 10	116 11 3	405 14 9	1,100 0 0	6 11 3

STATEMENT NO. 5

Cost per acre

Name of tractor	Ploughing	Disc-harrowing	Grubbing	Rolling	Drilling
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Lanz Bulldog semi-Diesel 15/30 H. P.	4 10 4	2 5 0	2 0 0	1 3 10	1 8 11
McCormick Deering 15/30 H. P. K. Oil	5 15 1	3 3 8	2 11 6	1 15 6	2 12 6
Vickers 23/40 H. P. K. Oil	4 13 1	2 14 0	2 13 0	1 15 0	2 1 7

Statement showing the output, consumption and cost of belt pulley work by tractors for the year 1933-34

Name of tractor	Working hours	Fuel and lubricants, etc.	Wages of mistris and water carriers	Wages of repairing staff	Spare parts	Total	Expenses per hour
		Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
McCormick Deering 15/30 H. P. K. Oil	89·91	179 5 4	17 4 7	49 10 6	239 2 6	485 6 11	5 6 3
Vickers 23/40 H. P. K. Oil	25·25	70 1 10	4 3 11	17 14 9	62 5 9	154 10 3	6 1 11

2. Spread of implements

This line of investigation has been considerably handicapped by the fact that the crude-oil tractors now being worked, do not exactly rank up with any actual types of kerosine oil tractors they succeed, while the latest crude-oil track types are of far greater H. P. than is really required in this tract. Investigations on the lines of a hinged plough are being taken in hand and the possibilities of increasing or decreasing at will the gangs on a disc-harrow. The chief trouble, however, lies in the fact that at present an efficiently harnessed tractor of 40 H. P. is pulling a plough which is a solo implement and to all intents and purposes part of the tractor, for no other tractor, unless of similar H. P. can utilise it efficiently ; while if arrangements are made to stack a fleet of disc-harrows behind this tractor to produce efficiency, the headland required for this procession is enormous and small fields have to be left untouched. Drills and grubbers are the same, to be efficient they must be of maximum spread and this cannot but tend to increase the capital cost of implements based on the tractor H. P. All this points to the essential need of variable spreads, so that implements may be fewer and common to all sizes of tractor, and a large amount of capital now invested in idle implements may be set free for other work.

3. Thresher

The bullock gear threshing outfit designed for work last year, details of which have been already published, worked for 112 hours over a period of 31 days and threshed wheat off 43·38 acres. The output was 490 maunds of grain.

During the year a hand winnower was designed and completed to work with the bullock gear outfit. It worked with the thresher throughout the season and proved very satisfactory in dealing with the output threshed daily.

The complete outfit now consists of :—

	Rs.
Thresher	450
Bullock gear	335
Winnower	230

and is available from Messrs. Arthur Butler & Co., Muzaffarpur (complete set for Rs. 1,000).

4. Dunlop Pneumatic Equipment for Bullock Carts

Four sets of wheels, tyres, axles and roller bearings were received from the Dunlop Company of India for trial on bullock carts.

They were fitted under four cart bodies (one iron and three wooden) specially designed and constructed here for heavy cane carting. They were fully tested throughout the season under loads of cane varying from 40 to 60 maunds carted either to the railway station (6 miles) or direct to the mill (14 miles).

They stood up to every test excellently and showed no sign of any wear and tear and reduced carting costs to a marked extent. The results of the trials have been written up and sent for publication. Further trials are in progress to test the farm life of the tyres.

XI. CATTLE BREEDING

The Pedigree Sahiwal herd stood at 217 head during the year under report. One cross bred cow alone remains in the milch herd (Appendix, Table I).

It will be noticed that though the milch herd numbers were reduced by twenty-one, the total milk yield remained at 3,00,690 lb. as against 2,99,990 lb. last year. The total quantity of milk sold during the year was 1,23 952 lb. as against 1,37,051 lb. in 1932-33.

Special calf rearing experiments in relation to early maturity.—These were continued during the year and account for the large quantity of milk fed to calves which was 1,20,302 lb. against 94,269 lb.

Pensioners and cows giving no milk, and only kept for breeding, were removed from the milch herd total in order to obtain a clear idea of the actual " in milk " percentage of the herd, while draft cows put aside for sale were similarly omitted. This has resulted in the " in milk " percentage of the herd rising from 55·1 to 66·2 (Appendix, Table II) which now gives an accurate idea of the actual figure. In past years this was frequently very low due to breeding cows which did not milk and cows pensioned off being included with the actual milking stock.

During the year under report the determination of the herd butter fat was done daily.

Berseem hay was fed to the herd from April to June and oat hay during the same period ; both of these have proved excellent dry fodder and have materially helped in maintaining a suitable ration for the herd. Feeding experiments are now in progress in collaboration with the Physiological Chemist to find out the exact food value of these fodders.

Milk yield.—The average herd yield per cow per day rose from 17·9 lb. to 18·7 lb. in the year under report. Four times milking was continued throughout the year and the highest herd yield per

PLATE I.

Fig. 1. Dunlop iron cart loaded with 600 bricks (60 mds.)

2. Dunlop iron cart loaded with 600 bricks (60 mds.)

Fig. 3. Dunlop wooden cart loaded with 650 bricks (65 mds.)

cow per day was 22·0 lb. for the month of April (Appendix, Table II). The second report on special feeding and handling was issued, and the experiment is now being carried on for the third year. A notable increase in the heifer yield was seen, and the figures for the last ten years are given for comparison (Appendix, Table III). All heifers were pre-milked and underwent the usual training which is now standard in the herd (See First Report on Feeding and Handling Experiments on the Pusa Pedigree Sahiwal herd).

No udder trouble of any description was experienced during the year. All cows are milked out prior to calving and no trouble is experienced even with the heaviest yielders.

In Appendix—Table IV, the lactations of some of the best cows and heifers are given.

In Appendix—Table V, the list of cattle disposed of is given. Good prices were realised and the demand for the stock continued to be good. As usual, all male stock not upto standard was castrated before sale.

Calf rearing.—This year shows a large increase in the mortality among pail-fed calves, which has risen from 2·4 per cent. to 13·2 per cent. (Appendix, Table VI). This was entirely due to an epidemic form of enteritis with lung complications which occurred directly after the earthquake. This was in no way connected with the method of rearing adopted here, and the mortality figure is now nil.

The early maturity experiments were continued throughout the year and further data collected.

Bull Lakhan, who, as reported last year, started service at eighteen months, has continued to serve successfully and now at the age of three years is of full average size and weight. His calves are also fully upto standard and show no signs of any deterioration. On the female side, work is being continued and the heifers going to bull are of full average weight despite their early age. Much interesting and important data are being collected, and a first report will issue in due course.

The standard calf weights for special and ordinary feeding from birth to 52 weeks were worked out and a paper has been sent for publication.

Earthquake.—A severe earthquake was experienced on the 15th January, 1934. Buildings were badly shaken and much confusion caused, but not a single head of stock received any injury and the entire staff are to be praised for the plucky way in which during the earthquake, without any thought of their own risk, they extricated all cattle from the buildings, which in some cases were near collapsing.

Lines of work

1. To establish milk ;

2. To improve milk yield ;

3. To fix a type incorporating as far as possible the physical characters of the best milkers ;

4. To definitely grade out all beef type transmitters from the herd ;

5. To fix certain definite characters in the breed which are regarded as essential by all judges and breeders ;

6. To adopt a system of advance registry ;

7. To trace and fix certain characters transmissible and hereditary and link them definitely with certain lines ;

8. To grade the whole milch herd into classes ;

9. To establish definite data for the correction of milk records in order to bring them into line with other herd records ;

10. To discover and record the best method of feeding, milking and handling the breed linked with the question of reabsorption of milk ;

11. To work out the possibility of higher feeding with earlier maturity, increasing the earning period of each cow ;

12. To settle the most profitable calving intervals for each lactation ;

13. To study carefully the effect of all line-breeding already done and its guide to subsequent work ;

14. The effect of in-breeding on the yield, constitution and general condition of the Sahiwal, particularly with relation to fertility ;

15. To investigate any Mendelian ratio which may be evident in transmission and to endeavour to trace any definite line of inheritance of characters under this law.

XII. PUBLICATIONS

1. Wynne Sayer . . . Berseem as green fodder, hay and silage, *Agri. and Live-stock in India*, 1934, **4**, 21-28.

2. ——— . . . Feeding and Handling Experiments on the Pusa Pedigree Sahiwal Herd, 1932-33 (First Report), *Agri. and Live-stock in India*, 1934, **4**, 105-126.

3. ——— . . . The Study of Threshing Problems at Pusa, *Agri. and Live-stock in India*, 1934, **4**, 197-207.

4. ——— . . . Mill Trial of Co. 299, *Agri. and Live-stock in India*, 1934, **4**, 407-411.

(Articles in the Press.)

5. Wynne Sayer	Early Maturity Experiments.
6. Wynne Sayer and Vaidyanathan, M.	Ideal size and shape of sugarcane experimental plots based upon Tonnage Experiments with Co. 205 and Co. 213 conducted at Pusa.
7. Wynne Sayer	Feeding and Handling Experiments on the Pusa Pedigree Sahiwal Herd (Second Report, 1933-34).
8. ————	Tests on Dunlop Pneumatic Equipment for Farm Carts, Season 1933-34.
9. ————	Tables of Pail-fed Calf Weights during Ordinary and Special Feeding.

XIII. PROGRAMME OF WORK FOR 1934-35

1. Cultivation investigation with special reference to production of tilth and condition of soil associated with speed of implements.

2. Green-manuring investigations with special reference to water requirements in various soils and conditions required by different crops.

3. General treatment of a 600-acre farm with special reference to reduction of costs in cultivation and the rotations suitable to the introduction of machinery.

4. Line-breeding investigations with a pedigree herd of Sahiwal cattle with special reference to the transmission of milch characters.

5. Experiments on feeding and digestion trials in collaboration with the Physiological Chemist to determine the digestive capacity of Indian cattle.

6. Special feeding of young calves with a view to early maturity to lengthen the profit period of the average Sahiwal cows and bulls.

7. Investigation of the threshing problem in India and the design of a small threshing plant to suit all-India requirements.

8. Experiments with various types of motor tractors and general tractor implements for collection of data and determination of most suitable types of tractors and implements for Indian conditions.

Collaboration with manufacturers with regard to the manufacture and test of new types of implements built to correlate with present tractor design.

9. Investigations on silage problems.

10. Experimental work—

(*a*) The design, layout and general technique connected with modern field experiments.

(*b*) Trials of new varieties of crops.

(*c*) Manurial experiments.

(*d*) Trials of sugarcane varieties suitable for growth without irrigation for various classes of soils and withripening dates corresponding to the alteration in factory conditions.

(*e*) Rotational experiments.

(*f*) Crop experiments in collaboration with Sectional Officers.

11. Training of post-graduate students.

12. Touring and advisory.

APPENDIX

TABLE I

Annual statement of Live-stock as it stood on the 30th June, 1934

Serial No.	Breed and description of cattle.	No. of animals from last year	Increase			Decrease					Total
			By birth	By transfer	Transfer from N. Area	By death	By transfer	By sale	Transferred to Estate and Farm	Sent to Pinjrapole	
	Sahiwal Cattle										
1	Bull	10	..	3	..	3	..	..	..	..	10
2	Cow	80	..	25	..	2	13	27	..	4	59
3	Young male stock	60	33	..	..	8	3	18	12	..	52
4	Young female stock	67	36	..	..	3	12	5	..	..	83
	Progeny of Sahiwal cows and Ayrshire bulls.										
5	Cow	2	..	..	..	..	..	..	..	1	1
	Miscellaneous crosses										
6	Cow	1	..	..	..	..	..	..	..	..	1
7	Young male stock	1	..	..	..	..	..	..	..	..	1
8	Young female stock	1	..	..	..	..	..	..	..	..	1
9	Cart bullocks	5	..	..	8	..	4	..	..	..	9
	Total	227	69	28	8	16	32	50	12	5	217
10	*Sheep*—										
	Male stock	23	13	..	..	9	..	..	..	..	27
	Female stock	55	16	2	..	21	2	..	..	..	50
	Total	78	29	2	..	30	2	..	..	..	77

TABLE II

Statement of milk yield for 1933-34

Month	Yield (excluding stripping)	Average per day	Average yield per cow per day	NUMBER OF COWS IN MILK AND DRY			
				Total No.	In milk	Dry	Percentage in milk
	lb.	lb.	lb.				
July 1933 . .	29,518	952	17·3	80	55	25	68·7
August 1933 . .	28,060	905	16·8	80	54	26	67·5
September 1933 .	22,421	747	16·2	78	46	32	59·0
October 1933 .	20,604	665	16·6	79	40	39	50·6
November 1933 .	20,057	669	16·7	59	40	19	67·8
December 1933 .	21,369	689	18·1	60	38	22	63·3
January 1934 .	21,646	698	18·4	60	38	22	63·3
February 1934 .	20,442	730	18·7	61	39	22	63·9
March 1934 . .	24,886	803	21·1	57	38	19	66·6
April 1934 . .	26,474	882	22·0	47	40	7	85·1
May 1934 . .	23,821	768	21·9	50	35	15	70·0
June 1934 . .	21,460	715	20·4	51	35	16	68·6
AVERAGE .	23,396	769	18·7	63	41	22	66·2
Average for 1932-33	23,170	761	17·9	77	42	35	55·1

TABLE III

Sahiwal Heifers—Pusa Herd

Statement showing average yield per day, 1925—34

Year	January		February		March		April		May		June		July		August		September		October		November		December	
	No. of heifer	Average per heifer per day	No. of heifer	Average per heifer per day	No. of heifer	Average per heifer per day	No. of heifer	Average per heifer per day	No. of heifer	Average per heifer per day	No. of heifer	Average per heifer per day	No. of heifer	Average per heifer per day	No. of heifer	Average per heifer per day	No. of heifer	Average per heifer per day	No. of heifer	Average per heifer per day	No. of heifer	Average per heifer per day	No. of heifer	Average per heifer per day
		lb.		lb.		lb.		lb.		lb.		lb.		lb.		lb.		lb.		lb.		lb.		lb.
1925	11	7·7	6	9·7	3	13·0	3	11·9	3	11·0	4	12·1	5	14·8	5	13·8	6	12·4	4	12·5	8	10·0	10	9·5
1926	10	9·1	7	10·2	12	8·8	14	10·1	10	10·3	10	10·3	13	10·1	14	9·6	14	9·7	16	8·6	15	8·3	14	7·8
1927	10	7·8	9	8·0	10	8·4	10	10·4	17	10·7	16	9·5	16	8·9	19	8·8	19	9·9	19	8·7	16	8·7	19	8·9
1928	17	9·8	12	9·8	12	8·5	6	12·3	6	12·1	7	13·7	6	13·9	6	12·4	7	12·5	5	13·2	3	13·3	7	12·9
1929	7	10·4	7	10·0	6	10·5	6	10·4	11	11·0	14	10·6	10	12·2	10	11·6	11	10·3	12	9·7	11	10·8	13	10·1
1930	12	11·4	14	9·5	13	9·9	13	9·3	12	9·6	10	9·9	11	9·2	11	7·5	14	7·6	13	7·3	10	6·9	8	7·9
1931	8	9·2	7	9 6	7	10·2	9	10·9	10	11·2	10	10·7	11	11·3	12	12·1	12	12·7	12	11·1	10	10·3	10	10·7
1932	9	9·3	10	8·8	13	11·3	12	12·1	11	12·3	9	12·0	8	11·3	8	12·9	8	13·8	9	15·6	8	15·1	8	15·1
1933	8	15·8	13	16·3	15	14·2	19	11·8	23	11·4	21	11·7	20	9·2	20	7·8	13	8·0	9	9·1	9	9·2	8	10·2
1934	6	10·3	5	11·9	5	19·2	4	21·5	6	19·2	8	18·1												

Table IV

Milk yield of some of the best cows and heifers during 1933-34.

Name and No. of cow.	Date of birth	No. of calving	Milk yield lb.	(Days)
Cows				
1. Ramati 566	19-3-27	3	8,327	(304)
2. Ajbi 567	10-5-27	3	8,015	(304)
3. Adami 503	25-5-24	5	7,850	(303)
4. Nasoorti 427	8-3-21	8	7,546	(304)
5. Lalagi 596	6-1-29	2	7,425	(304)
6. Makhi 557	14-10-26	4	7,082	(306)
7. Lakhni 587	8-5-28	3	7,009	(304)
Heifers				
1. Brisoorti 609	28-2-30	1	6,036	(303)
2. Birkli 615	3-6-30	1	4,479	(306)
3. Lachrama 612	11-4-30	1	4,042	(289)

Table V

Statement showing the disposal of cattle during 1933-34

		Price	Average
		Rs.	Rs. A. P.
16	Sahiwal young bulls . .	880	55 0 0
23	,, cows . . .	3,020	131 5 0
4	,, heifers . . .	355	88 12 0
Total 43			
4	Sahiwal cows sold on nominal price.		
10	,, steerlings—transferred to Farm.		
2	,, ,, —transferred to Estate Office.		
4	,, cows }		
1	½-Ayr. Sahiwal cow } —sent to Samastipore Pinjrapole.		
3	Young bull-calves sold with cows.		
Total 67			

TABLE VI

Calf mortality figures (Pail-fed period)

Year	Birth	Death	Percentage of mortality	
1932-33 . . .	84	2	2·4	
1933-34 . . .	68	9	13·2*	*Due to enteriris.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S.)

(1) BOTANICAL SECTION, PUSA.

I. ADMINISTRATION.

Dr. Shaw held charge of the Section throughout the year under report. Dr. B. P. Pal, M. Sc., Ph.D. (Cantab.), F.L.S., was appointed Second Economic Botanist with effect from the 30th October, 1933. Mr. Kashi Ram held the post of Officiating Assistant Economic Botanist upto the 10th April after which he was transferred to Karnal as Officiating Superintendent of the Botanical Sub-Station. Mr. R. D. Bose was confirmed in the class II post of Special Research Assistant with effect from the 1st March 1934 and was appointed as Officiating Assistant Economic Botanist from the afternoon of the 10th April *vice* Mr. Kashi Ram transferred to Karnal. Mr. R. B. Deshpande was confirmed as an assistant on the 1st March and appointed to officiate as Special Research Assistant from the 27th April, 1934. Dr. A. A. Quarashi, Ph. D., officiated as an assistant from the 2nd January to the 28th February, 1934.

A sum of Rs. 1,945-1-9 was realized from the sale of improved seeds, etc., and credited to Government during the financial year ending the 31st March, 1934. Owing to the great increase in experimental work, the area allotted to bulk crops is annually decreasing in the Botanical Section and hence the work of multiplying and distributing seed of improved types of crops has to be largely carried out on the Pusa Farm in collaboration with the Imperial Agriculturist and at the Botanical Sub-Station at Karnal.

Training.

Mr. S. Majid, B.Sc., completed his post-graduate training during the year and was of material help in the investigations with which he was concerned.

Messrs. Sarvayya Chetti, Pushkar Nath, Abdul Aziz, S. V. A. Hydari and M. P. Bhatnagar continued to receive their training. Mr. P. Krishna Rao, Parlakimedi Scholar from Madras, Mr. S. B. Vaidya, King Edward Scholarship holder from the Central Provinces, and Messrs. A. Pal and S. Z. Hasanain, private students from Bengal and the United Provinces respectively, were admitted this year for the full post-graduate course in Economic Botany.

All these students were sent to Karnal in the second week of March, for about a week, in order to study the growth and behaviour of crops under irrigated conditions.

Mr. T. C. N. Singh, Officiating Assistant Economic Botanist, Bihar and Orissa, Sabour, and Mr. R. B. Ekbote, Farm Assistant, Karnal, were given a special course of lectures on the lay-out and statistical interpretation of field trials in July, 1933.

Three students from the Agricultural Section and two from the Chemical Section were permitted to attend the course of lectures delivered in this Section on biometry and statistical methods. One of the Agricultural students continued to attend the lectures on genetics also.

Messrs. San Maung (Burma), S. N. Choudhury and B. R. Mandal (Bihar and Orissa), H. S. Gupta and Inam Ahmed (United Provinces), Ram Dittamal (Punjab), Lodhi A. K. Khan (Sind), B. Subba Rao (Central Provinces), and Gopal Ratnam (Madras), were admitted in January 1934 for a special course of training in flue-curing of tobacco. Owing to a severe hailstorm which damaged the tobacco crop and because of the earthquake of the 15th January damaging the flue-curing barn, the course was curtailed.

Season and Rainfall.

The rains commenced rather early and the total annual rain fall exceeded the average for the last 25 years by 6·28 inches. The distribution was fair though July received an excess of 7·87 inches. The year was a very bad one as far as rusts are concerned for the attack of both wheat and linseed rusts was very severe, particularly of the latter. The unusually heavy incidence may have been due to rather heavy rain in January.

Statement of rainfall in the Botanical Section in 1933-34.

Month	Average for last 25 years. 1906—1930	From 1st June 1933 to 31st May 1934	Difference
June 1933	7·53	8·57	+1·04
July ,,	11·08	18·95	+7·87
August ,,	14·09	10·98	—3·11
September ,,	8·05	9·35	+1·30
October ,,	1·81	2·25	+0·44
November ,,	0·43	0·00	—0·43
December ,,	0·18	0·00	—0·18
January 1934	0·34	1·94	+1·60
February ,,	0·68	0·45	—0·23
March ,,	0·41	0·07	—0·34
April ,,	0·56	0·00	—0·56
May ,,	1·44	0·32	—1·12
Total	46·60	52·88	+6·28

The most noteworthy features of the season were the hailstorm of the 13th January, 1934, and the great earthquake of the 15th January. The former completely ruined the tobacco crop and also caused wheat, barley, *rahar*, etc., to lodge. The earthquake was responsible for the appearance of a moderate sized fissure in Barah 4 plot through which a certain amount of water followed by sand was ejected ; no further damage to land was done in the Botanical Section except near the bhusa shed which was the only building badly damaged in the Section.

Statement showing the seed distribution in 1933-34 of improved crops evolved in the Botanical Section, Pusa.

Crop	Variety	Quantity distributed in lb.		Total
		By the Botanical Section, Pusa	By the Pusa Farm	
Barley	Type 1	20·5	..	20·5
	,, 2	14·5	..	14·5
	,, 7	1·0	..	1·0
	,, 12	11·0	..	11·0
	,, 19	1·0	..	1·0
	,, 20	11·0	..	11·0
	,, 21	1422·0	1647·0	3069·0
	,, 22	15·0	..	15·0
	,, 23	15·0	..	15·0
	R-1	10·0	..	10·0
Chillies	Type 34	1·6	..	1·6
	,, 38	·1	..	·1
	,, 41	1·1	..	1·1
	,, 46	·6	..	·6
	,, 51	1·2	..	1·2
Ganja	Type 1	164·6	..	164·6
Gram	Type 2	1·5	..	1·5
	,, 6	42·6	..	42·6

Seed distribution in 1933-34—(contd.)

Crop	Variety	Quantity distributed in lb.		Total
		By the Botanical Section, Pusa	By the Pusa Farm	
Gram—*contd.*	Type 17 . .	285·6	2633·1	2918·7
	„ 25 . .	229·4	966·9	1196·3
	„ 28 . .	255·5	..	255·5
	„ 58 . .	278·6	246·9	525·5
	„ 51 . .	6·5	..	6·5
	„ 48 . .	6·5	..	6·5
	„ 49 . .	6·5	..	6·5
	„ 53 . .	49·0	..	49·0
	„ 54 . .	16·6	..	16·6
	„ 67 . .	22·8	..	22·8
Lentil . . .	„ III-86 . .	55·9	658·3	714·2
	„ 47 . .	·3	..	·3
	„ III-54 . .	·3	..	·3
	„ III-55 . .	·3	..	·3
	„ 220 . .	·3	..	·3
Linseed . . .	„ 12 . .	130·0	..	130·0
	„ 121 . .	78·0	..	78·0
	„ 124 . .	56·6	..	56·6
	Hybrid 10 . .	321·0	..	321·0
	„ 21 . .	47·0	..	47·0
	„ 38 . .	7·5	..	7·5
	„ 55 . .	72·0	..	72·0
	„ 68 . .	65·8	..	65·8
Oats	B. S. 1 . .	278·0	39498·3	39776·3
	„ 2 . .	83·0	1152·0	1235·0
	Hybrid A . .	4·0	..	4·0
	„ B . .	4·0	..	4·0

Seed distribution in 1933-34—(contd.)

Crop	Variety	Quantity distributed in lb.		Total
		By the Botanical Section, Pusa	By the Pusa Farm	
Oats—*contd.*	Hybrid C	343·0	987·4	1330·4
	„ D	4·0	165·6	169·6
	„ E	4·0	..	4·0
	„ F	4·0	..	4·0
	„ G	24·0	..	24·0
	„ H	4·0	..	4·0
	„ I	4·0	..	4·0
	„ J	87·0	..	87·0
	„ K	4·0	..	4·0
Paddy	Type 24	258·1	..	258·1
	„ 31	518·1	..	518·1
	„ 52	309·1	..	309·1
	„ 18	13·1	..	13·1
	„ 60	10·0	..	10·0
	„ 97	20·0	..	20·0
Patwa	„ 3	·1	..	·1
	„ 6	41·1	..	41·1
	New Patwa	164·0	..	164·0
Pea	Type 14-1	..	205·7	205·7
Rahar	„ 6	1·0	..	1·0
	„ 15	30·0	164·6	194·6
	„ 16	136·1	..	136·1
	„ 24	11·5	205·7	217·2
	„ 41	1·0	..	1·0
	„ 50	1·0	..	1·0

Seed distribution in 1933-34—(contd.)

Crop	Variety	Quantity distributed in lb.		Total
		By the Botanical Section, Pusa	By the Pusa Farm	
Rahar—contd.	Type 51	235·4	374·4	609·8
	,, 64	22·0	..	22·0
	,, 69	1·0	..	1·0
	,, 80	10·0	82·3	92·3
	,, 82	22·0	..	22·0
Rai Seed	....	4·0	..	4·0
Safflower	Type 30	102·1	..	102·1
Sarson Seed	....	4·0	..	4·0
Sesamum	Type 3	1·5	..	1·5
	,, 7	2·5	..	2·5
	,, 29	11·9	..	11·9
	,, 30	·3	..	·3
Tobacco	,, 28	15·6	..	15·6
	,, 58	·013	..	·013
	,, 63	·013	..	·013
	N. Rustica Type 18	2·6	..	2·6
	Hybrid 142	·025	..	·025
	,, 177	3·5	..	3·5
	Cash	·013	..	·013
	Adcock	1·1	..	1·1
Wheat	Pusa 4	35·3	658·3	693·6
	,, 12	506·0	6697·0	7203·0
	,, 52	89·0	1664·2	1753·2
	,, 80—5	195·0	..	195·0

Seed distribution in 1933-34—(concld.)

Crop	Variety	Quantity distributed in lb.		Total
		By the Botanical Section, Pusa	By the Pusa Farm	
Wheat—*contd.*	Pusa 101	37·5	1241·6	1279·1
	,, 111	47·0	1188·0	1235·0
	,, 112	43·0	..	43·0
	,, 114	32·0	..	32·0
	,, 120	41·0	..	41·0
	,, 165	41·5	..	41·5
	,, 113	2·0	..	2·0
	,, 12-2 (New)	61·0	..	61·0

II. INVESTIGATIONS.

Wheat (*Triticum vulgare* Host).

Although in the year under report rust was unusually severe, the yields were, as a rule, above the average. The highest yielders at Pusa were Pusa 101 which grown on an area of 0·32 acre gave an outturn of 2584·4 lb. per acre and Pusa 52 which grown on an area of 0·65 acre gave an outturn of 2449·5 lb. per acre. The bushel weights, however, were lower than those of last year, though with the exception of Pusa 12 higher than the average for the past few years. This may be seen from the following table :—

Table I.

Showing bushel weights of some Pusa wheats.

Variety	Weight per bushel in lb.		
	Average for the past six years ending 1931-32	1932-33	1933-34
Pusa 4	63·68	66·3	64·36
Pusa 12	61·93	64·3	59·76
Pusa 52	64·00	66·4	65·67
Pusa 101	..	67·1	65·77
Pusa 111	..	66·1	64·58

Pusa 114 has proved to be a great success in Sind and during the present season has been sold at a premium of 12 per cent. It has also given very high yields in the Punjab. Pusa 101 yielded over 33 maunds (2715·4 lb.) per acre at the Government Agricultural Farm, Meerut, where it was grown on an area of one-tenth of an acre and 27·7 maunds (2279·3 lb.) at Sepaya, and a report from Bhopal stated that this wheat " appears to have possibilities for local spreading and being largely rust resistant should also be better than some of the C. P. types ". Pusa 52 yielded 32 maunds 26 seers 4 chataks (2687·1 lb.) per acre at Meerut and 26 maunds at Sepaya. Pusa 80-5 gave over 40 maunds (3291·4 lb.) per acre at Meerut where it was grown over an area of one-tenth acre.

The most promising of the hybrids obtained from crosses between the Australian variety Federation and Pusa 4 and Pusa 52 were tested against the two Pusa parent types and were under yield trial for the second year. The yield trial was laid out in duplicate, one Latin square being put in a manured, and the other in a non-manured field. In the latter Pusa 52, *i.e.*, one of the parent varieties, was significantly better than the hybrids ; in the former, however, Pusa 52 though superior to the other hybrids, was surpassed in yield by Hybrid 61-1-1-3, the difference being statistically significant. Although most of the hybrids are not superior to the parent varieties in yield, some of them nevertheless possess certain desirable features such as resistance to disease which may render them of agronomic value. Two of them, now designated as Pusa 120 and Pusa 165 which gave very good results at Karnal were tried out on various farms in the Punjab and in the United Provinces. The results of these trials are being awaited with interest. Pusa 12-2, a strain bred from a rogue plant in Pusa 12, was tried on a large scale this year and was found to be similar to Pusa 12 in yielding capacity.

Pusa 52 and a local wheat obtained from the Deputy Director of Agriculture, Muzaffarpur, were tested this year for the second time, the form of lay-out adopted being the parallel strip method. The average yield per acre of Pusa 52 was 1219·65 lb. while that of the local variety was only 884·78 lb., the difference being statistically significant. Though beaten ultimately in growth, tillering and yield, the local variety looked more vigorous in the early stages because of its erect habit and greater height, Pusa 52 having a semi-erect habit.

A vernalization experiment with Pusa 101 and Punjab 8A wheats proved to be insignificant, the treated and non-treated plots giving similar results.

F

Barley (*Hordeum vulgare L.*).

Barley continued to receive a good deal of attention in the Botanical Section. A number of qualitative and quantitative characters were studied in great detail in the F_3 generations of two crosses, *viz.*, type 21 × type 1 and type 21 × Nepal hooded barley. The data are being analysed and the mode of inheritance of different characters will be determined from this. In the cross type 21 × type 1, the mother parent, type 21, is a 6-rowed barley and the male parent, type 1, is a 2 rowed barley which differs from all other Pusa barleys in possessing broad outer glumes in the ear-head. It has been found that single factors are responsible for the inheritance of the following characters :—

(1) Fertility of the lateral florets—the ratios of 2 rowed : intermediate : 6-rowed being as 1 : 2 : 1.

(2) Awns on the inner glumes of the lateral florets—1 nil : 2 intermediate : 1 full.

(3) Nature of outer glumes—3 narrow : 1 broad.

The inheritance of items (1) and (2) seems to depend upon the interaction of the same genetic factors and there appears to be a complete linkage between :—

2-rowed fertility and no development of awns on the lateral florets,

Intermediate fertility and the development of pointed or tipped awns on the lateral florets, and

6-rowed fertility and development of fully developed awns on the lateral florets.

There is no linkage between fertility and nature of outer glumes and (1) maturity as measured by the number of days taken by individual plants to head out, (2) length of ear-heads and (3) internode length as represented by the length of 10 internodes in cm.

In the case of the other cross, *viz.*, type 21 × Nepal hooded barley, the hooded character seems to be dominant to the awned, the proportion being three hooded to 1 awned, but the presence of many grades of hooded character indicates that more than one factor is responsible for this inheritance.

In a cross between the 2-rowed Chevalier and the 6-rowed Pusa type 21 barley, 21 plants out of a total population of 374 in the F_2 generation were observed to possess branched ear-heads in 1931-32. Neither the two parents nor the F_1 hybrids showed this feature but the F_2 and the following two generations showed that duplicate factors were responsible for the inheritance of this character and that the branched ear genotype was the double recessive. It was

also found that the factors for branched ears segregated independently of the factors for the fertility of the lateral florets. A paper on this subject has been submitted for publication.

In a cross between a lodging (type 1) and a non-lodging (type 21) barleys, the examination of F_2 plants by cutting transverse sections of the culms disclosed that the development of mechanical tissues is also controlled by Mendelian factors. In the non-lodging phenotypes, the sclerenchyma is thick and well developed and there are regular sub-epidermal girders which help to strengthen the culm ; in the lodging type, on the other hand, it has been found that the sclerenchymatous tissue is poorly developed and there are hardly any sub-epidermal girders present. The F_3 study will confirm the nature of segregation for this character.

Helminthosporium causes a serious disease of barley and investigations are in progress in collaboration with Dr. Mitra of the Mycological Section, Pusa, regarding the comparative susceptibility to this fungus of the twenty-four types of barley evolved at Pusa. Details of this work will be found in the report of the Imperial Mycologist. The different types vary in their resisting power but none of them have shown complete immunity to the disease. Partial control appears to be obtained by seed treatment and hence initial infection is due mostly to natural seed infection.

The study of the inheritance of resistance to *Helminthosporium sativum* P. K. and B. in two crosses of Pusa barleys has been conducted in the Botanical Section, and it is found that multiple genes are responsible for the inheritance of this character and that resistance to this disease is dominant to susceptibility. A paper on this subject has recently been sent in for publication.

A study of inheritance of striped leaves in barley is in progress and a preliminary study on the effect of vernalization in barley has been taken up.

Oats (*Avena sterilis L.*).

Favourable reports regarding the yielding power of B. S. 1 and 2 and hybrids C and J oats have been received from many parts of India, where they have been tried during the year under report. The response of different types to variations in soil and climate is very well elucidated by yield trials conducted for the last three years with eleven hybrids and B. S. 1 and B. S. 2 in two different places, *viz.*, Pusa and Karnal under different sets of conditions. At Pusa the crop was grown without irrigation while at Karnal the usual irrigations were given. Whereas in the first year of the experiment, *i.e.*, 1931-32, the yields of these thirteen types of oats varied considerably with the locality, the final conclusons based on the results of three seasons' investigations at each

place were more or less in agreement with each other. This is shown in the following table :

Average yields in lb. of Pusa oats taken from plots 1,000 square feet in area.

Year	Localities	Varieties												
		A	B	C	D	E	F	G	H	I	J	K	L	M
1931-32	Pusa	25·5	24·7	24·4	26·3	30·9	34·8	30·2	22·2	23·1	31·8	27·2	44·3	32·2
	Karnal	41·3	29·3	42·1	40·6	35·7	34·4	43·7	36·5	32·8	44·3	49·4	31·8	35·6
1932-33	Pusnal	34·0	29·4	59·1	45·1	46·3	50·3	54·4	34·0	53·7	56·7	37·2	52·3	57·2
	Karnal	36·6	26·1	47·7	43·5	43·6	37·5	50·2	36·0	35·6	53·7	38·5	55·9	57·5
1933-34	Pusa	47·3	34·9	67·9	49·9	54·1	45·4	56·1	48·5	50·8	56·1	45·8	59·5	63·8
	Karnal	43·4	31·2	43·7	41·0	42·7	41·9	43·6	36·8	43·3	42·1	40·3	43·7	50·6
Average of three years	Pusa	35·6	29·66	50·46	40·43	43·76	43·5	46·9	34·9	42·6	48·2	36·7	35·23	51·06
	Karnal	40·43	28·86	44·5	41·7	40·66	37·93	45·83	36·43	37·23	46·7	39·4	43·8	47·9

If we had considered the yields of the different oats during 1931-32 only and based our recommendations on these results, we would have concluded that at Pusa, L. (B. S. 1) was the best yielder and hybrid C a very poor yielder, whereas at Karnal in the same year hybrid C was one of the best yielders and L. (B. S. 1) a very poor one indeed. The two results were diametrically opposed to each other. If, however, we take the accumulated results of three seasons' trials at each place, we find that save for seasonal differences the two types were ranked quite high for their yielding power and were in fact statistically not different from each other in this respect. This shows how erroneous it is to base conclusions on the results of trials conducted in one season or in one locality only and the necessity of conducting serial trials for a more exact evaluation of the different treatments.

The complete statistical analysis of this accumulated data show that the five highest yielders are oat types M, L, C, J and G which are ranked in this order but types L, C, J and G are not statistically different from each other and may all be classed as yielders of the same order. Amongst these five oats M is statistically superior to G only and not to any others. Hybrids A, B, H and K on the other hand, have not done well and must be ranked as indifferent yielders. A paper giving complete details of this trial and the method of working out serial experiments is being written up for publication.

Another example of the influence of soil and climate on the yielding power of some of these oats is furnished by the result

obtained during the present year from a trial conducted by the Byreah Farm in the Bettiah Raj in North Bihar where B. S. 1 (P. 1) oats has significantly out-yielded hybrids C, F and J. The mean vareital differences together with the critical differences are shown below :—

Mean varietal differences in lb.

Varieties	C	P1	J	F
C	..	+6·08	+3·72	—0·38
P1	—6·08	..	—2·82	—6·46
J	—3·72	+2·82	..	—3·64
F	+0·38	+6·46	+3·64	..

Critical differences—

Differences greater than 3·05 and marked ———— are significant at the 1 per cent. level of significance.

Differences greater than 2·20 and marked ———— are significant at the 5 per cent. level of significance.

Paddy (*Oryza sativa L.*).

The work of isolating paddy types was completed in the year under review and 123 types have been finally retained. The most promising of these were put under preliminary yield trial and one autumn paddy (type 18) and three winter paddies (types 24, 31 and 52) have been picked out as being worthy of large scale tests.

Colour development in the paddy plant has been studied, particularly in the floral organs and a paper on this subject has been sent in for publication. The rices of Bihar and Orissa have been classified on the basis of this study and a paper on this classification has also been sent for publication. The main divisions of this classification are based on the chemical constitution of the rice kernel, presence or absence of clustering in spikelets, presence or absence of double-grained spikelets, length of the outer glume, and upon the presence or absence of elongated internodes with the production of aerial roots at the nodes. Next to this the colour of the inner glume has been deemed to be the most suitable criterion as the inner glume exhibits a wide range of easily distinguishable colours and affords a ready and convenient means of discrimination between varieties. After this the colour of the apiculus was considered to be the most suitable criterion and two distinct types of

apiculus colour designated as "restricted" and "spreading" apiculus respectively were distinguished. After the apiculus the colour of the outer glume is used and thereafter the colour of the kernel and internode and finally the grain size and shape are used in separating the ultimate classes.

Preliminary observations were made on the tillering capacity of certain varieties.

Maize (*Zea mays L.*).

The study of the inbred lines was continued and artificial pollination was performed to raise the selfed lines next year. It is also proposed to grow a collection of samples of maize obtained from different parts of India.

Rahar (*Cajanus indicus* Spreng).

An yield trial was again carried out with 10 promising types selected at Pusa and the local variety. Types 24 and 64 again proved to be significantly better yielders than the latter. The types in this yield trial experiment as well as the *rahar* grown in other plots were considerably damaged by the hailstorm of the 13th January. The flowers and pods of the *rahar* crop were damaged and the crop lodged badly owing to strong winds. In a preliminary trial with Pusa, types 15, 16, 41, 50, 80 and 82, No. 80, a wilt resistant type, occupied the first position at Sabour Farm, and types 24 and 51 did fairly well at Sepaya Farm. Type 51 is reported to have shown resistance to frost injury at Gwalior Farm.

The work on the inheritance of wilt-resistance in *rahar* or pigeon peas has been completed and is being written up for publication. It has been found that inheritance of wilt-resistance in this crop depends on the interaction of multiple factors and that these factors are inherited independently of the factors which are responsible for the inheritance of flower colour, seed colour, type of inflorescence and habit, as the phenotypic proportions among the survivors of an F_2 population in a wilt-infected field remained undisturbed.

During the year under review two F_2 populations which were grown in 1932-33 were carried to F_3 in infected fields in 1933-34. One of these populations was the complete progeny of a single F_1 plant and was grown under normal, uninfected conditions and contained 193 individuals and will be referred to as the 'B-Series'. The other F_2 population was also the progeny of a single F_1 plant and was grown under artificially infected conditions. In this population there were 98 survivors, the seed of which was carried to F_3, and this will be referred to as the 'A-Series' in the following table which shows the distribution of the loss due to wilt disease among the F_3 families and the parent types.

Frequency distribution of the number of cultures with different degrees of wilt infection in Rahar cross Type 5 × Type 80-F_3 grown in infected fields.

Year and Series	Seed	No. of cultures with different percentages of wilt infection										Total
		0	10	20	30	40	50	60	70	80	90	100	
1933-34 Series A	F_3	2	2	8	13	9	9	18	15	14	7	1	98
	Type 5	..	..	..	..	..	..	..	..	..	..	9	9
	Type 80	7	3	1	1	..	..	..	..	..	..	..	12
1933-34 Series B	F_3	1	11	20	23	18	30	16	18	10	10	36	193
	Type 5	..	..	..	..	..	1	2	2	1	1	17	24
	Type 80	2	..	..	..	..	..	..	..	..	..	..	2

These frequencies suggest that in the A Series most of the susceptible plants had been destroyed by disease in the F_2 and that in F_3 these susceptible plants would have been non-resistant individuals which would be either heterozygous for factors for resistance or homozygous for their complete absence, while in the B Series in which elimination of the more susceptible genotypes in F_2 had not taken place, about 18 per cent. of the total number of cultures in F_3 have a death rate of over 90 per cent. In both the series, however, the distribution of resistance and susceptibility among the F_3 families shows that the inheritance of this disease is dependent upon multiple factors.

Gram (*Cicer arietinum L.*).

The results of the cross between a kabuli type (Pusa No. 2) and a desi gram (Pusa No. 18) are being sent up for publication. The hybridisation work was continued at the Botanical Sub-Station, Karnal, in collaboration with the staff there and will appear in the report of that station.

Eight types, Nos. 48, 49, 51, 53, 54, 55, 58 and 67 were compared in yield with the old established types 17 and 25 in a randomised blocks lay-out with 6 replications. None of these surpassed type 17 this year, but type numbers 51, 54, 55 and 58 were significantly better than type 25 at the 1 per cent. level of significance. The latter was also significantly inferior to T. 17. The types that were best this year were Nos. 17, 51 and 58 and the difference between them was insignificant. Types 48 and 49 were the worst in yield and were badly attacked by blight. As these two types did not do well last year also, they have now been rejected from the yield trial.

Type 58 was significantly superior to type 17 in the past 2 years and this year, which is apparently not a favourable season for Type 58, the two are about equal. The reports received from various stations show that at these places type 58 has given higher yield than T. 17 or T. 25 but unfortunately no regular yield trials were conducted at these stations.

In a new yield trial types 17 and 41 were tested in parallel strips but the experiment was spoiled by an attack of cut-worm (*Agrotis Ypsilon*) which attacked T. 17 more severely than T. 41. The reason for this is being investigated.

The 84 types were maintained.

Peas (*Pisum sativum L.* and *P. arvense L.*).

The study of the types was continued and a paper describing these types is being written up for publication. The yield trial was repeated with 5 types, in a Latin square. The dwarf garden pea No. 14-1 again occupied the first position. The yield trial will be repeated next year when the final conclusions will be drawn.

Lentils (*Ervum lens L.*).

Six hybrid lentils were tried against two high yielding selections in an 8 × 8 Latin square and under the conditions of the experiment it was found that the latter outyielded all the hybrids and that the bold seeded-lentils invariably gave lower yields than the small seeded forms. This experiment, however, will be repeated for some years more and the final conclusions will be based on the accumulated results of these trials.

Urid and *Mung* (*Phaseolus Mungo L.* and *P. radiatus L.*).

The pure lines of these two crops are being maintained. The *urid* crop was almost a complete failure during the year because the plot under this crop was badly flooded. A preliminary yield trial with some promising strains of *Mung* has been started. The F_2 generation of a cross between a green seeded *Mung*, type 18, and a yellow seeded one, type 36, was studied. A single factor seemed to be responsible for the inheritance of flower and pod colour and at least two factors were concerned in the production of green and yellow coloured seeds.

Sunn-hemp (*Crotalaria juncea L.*).

The attempt to isolate a suitable strain of this crop continues and a preliminary study of the root system of different cultures evolved has been started. At the request of the Bengal Department of Agriculture and in collaboration with the Assistant Fibre

Expert, Bengal, a number of samples of Bengal sunn-hemp have been secured and the isolation of a suitable *rabi* strain for Bengal will be taken up this year. The ordinary *kharif* variety of this crop was sown during the *rabi* season this year but failed to develop normally.

Indian Hemp (*Cannabis sativa L.*).

Pusa types 1 and 2 of *ganja* were cured for the first time during the year under review and the product disposed of to the local Excise Department. Pusa type 1 appears to be a very promising strain for the production of the drug and some seed of this is being multiplied for large scale trials. About 2 maunds of seed were obtained from a crop of this type in an area of about one-fourth of an acre.

Tobacco (*Nicotiana tabacum L.* and *N. rustica L.*).

Observations on the F_4 of the cross between the white-flowered type 156 and the pink-flowered type 43 were continued. Some promising hybrids from this cross are undergoing curing trials. In connection with an experiment on the possible influence of the age at which fertilization occurs in flowers on the mendelian ratios in the progeny, flowers produced on a number of F_1 plants were selfed daily over a period of two months.

The large growings of type 142 tobacco for flue-curing this year produced a fine crop and some very good quality leaf was cured before the crop was damaged by a hailstorm on January 13th. Due to this it was not possible to save enough seed for distribution and numerous requests for seed of this hybrid tobacco had to be refused.

Chillies (*Capsicum annuum L.* and *C. frutescens L.*).

The original types were maintained. The work of isolating and fixing the Goa chillies was continued. Cultures which were segregating for fruit size and shape and hence very difficult to fix were rejected.

The F_2 generation of the cross, T. 3 × T. 11A, was grown and segregation for anther colour was studied. type 3 has bluish purple anthers while the anthers of type 11A are yellow. The F_1 was intermediate for this character. In F_2 the ratio of individuals with purple anthers (of various grades) to those with yellow ones was 3 : 1, indicating a monohybrid segregation. A number of F_2 plants were selfed in order to grow an F_3 generation to confirm the F_2 results.

A new cross to study the inheritance of colour of unripe fruit (green : white) was made between type 1 and type 2.

A paper entitled "Studies in Indian Chillies. (4) The Inheritance of Pungency in Capsicum annuum L." was written up and sent for publication.

HIBISCUS (*H. cannabinus L.* AND *H. sabdariffa L.*).

The original types were maintained. A few types of *H. cannabinus L.* received from Russia were also grown. These are very short in height and early in maturity and because of the former character are not expected to be useful from the economic view point. They can, however, be used for crossing purposes.

The F_1 generation of the cross between a type (T. 6) of *H. cannabinus L.* and a variety from Russia made in order to study the inheritance of plant height and maturity was grown. The first parent is very tall and takes about 80 days to flower while the second parent is very dwarf and takes only about 40 days to flower. The F_1 was intermediate for both these characters. About half a dozen of these F_1 plants have been selfed to provide seed for growing the F_2 generation.

The F_2's of the crosses, New Hibiscus (*H. Sabdariffa* var. altissima) and *Albus* and New Hibiscus and *Ruber* were repeated in order to carry some red stemmed plants (of all grades), selected at random, to the F_3 generation to corroborate the previous F_3 results relating to the inheritance of stem colour.

Some promising fixed hybrids from the crosses, New Hibiscus × *Albus* and New Hibiscus × *Ruber*, were grown and specimens of a few of these were sent to the Fibre Expert to the Government of Bengal, Dacca, for preliminary fibre tests.

To investigate the effect of age of the F_1 plants on the mendelian segregation in F_2 a number of F_1 plants of two crosses of Hibiscus, New Hibiscus × *Albus* and New Hibiscus × *Ruber*, were made in the year 1931-32, and in the year following the F_1 was raised. The flowers on these F_1 plants were selfed, as they were produced, on each successive day. In the year under review the selfed seeds from these F_1 plants were grown separately date by date, and the segregation in the F_2 progeny thus obtained was studied. Two characters were considered, leaf-lobe, narrow or broad, and stem colour, red or green. The ratio of the dominant character to the recessive was calculated for each of these days, and it was found that the ratio did not show any periodical increase or decrease in either phenotype from day-to-day. The combined ratio for the total flowering period was in accordance with theoretical expectation. Unfortunately the population was rather small because of the poor germination occasioned by heavy rain falling immediately after sowing. It is proposed to repeat the experiment next season. Another set of F_1 plants was grown and the flowers selfed on successive days as in the previous experiment. A much larger quantity of seeds has been harvested this time.

Linseed (*Linum usitatissimum L.*)

The 105 fixed hybrids and the 124 original types were grown. The latter were grown after a lapse of three years. Due to a bad attack of rust (*Melampsora Lini*) the seeds did not develop well and hence the intention of getting the oil content analysed and the seed size measured was abandoned.

Last year's yield trial experiment with seven hybrids and one standard type, type 12, was repeated and a preliminary yield trial with fourteen new hybrids and type 12 was also laid out in the form of "randomized blocks". Both these experiments were vitiated due to severe rust (*Melampsora Lini*) and it is proposed to repeat them next year.

The F_3 of the following crosses was grown and studied. T. 15 × T. 12, T. 15 × T. 20, T. 15 × T. 22, T. 1 × T. 24 and T. 4 × T. 24. The dihybrid segregation for petal colour in F_2 in the crosses, T. 15 × T. 12, T. 1 × T. 24 and T. 4 × T. 24, and the monohybrid segregation in the cross T. 15 × T. 22 were confirmed. The F_3 of T. 15 × T. 20 indicated that type 15 differed from T. 20 by two factors for petal colour, and that the bad fit in F_2 was due to the wrong diagnosis and grouping of different phenotypes. For instance one F_3 culture, from a culture noted down as T. 20 L (petal like T. 20 but lighter) segregated like F_2 although it was expected to segregate differently (1 T. 20 : 2 T. 20 L. : 1 T. 15). The F_2 may have to be repeated.

The F_2 of the crosses T. 12 × T. 24 and T. 21 × T. 24 was grown and the segregation for petal colour was studied. In both the crosses a dihybrid segregation of 9 blue like F_1 : 3 blue like T. 24 : 4 blue like the other parent was obtained. A number of F_2 plants representing the different phenotypes has been selfed to carry to the F_3 generation for confirming the F_2 results.

An experiment to obtain an individual in which all colour factors are absent so that it could be used as a tester for types with unknown genetical constitutions has been started. When such an individual is isolated, it should be possible to ascertain the genetical constitution of any new type by crossing them together and growing the first generation only, thereby saving time, labour and land.

The bold-seeded Australian linseeds which are rather late for this part of India were sown about two weeks earlier than the usual sowing time. The seeds developed well and it is expected that a true idea of their oil yielding capacity will be obtained this year. The samples have been submitted for chemical analysis.

Besides the large seed-size these linseeds possess another good feature : they are immune to rust (*Melampsora Lini*). Some of these have been crossed with the high yielding indigenous types and fixed hybrids, with the object of combining in one type, high yield, high

oil content and resistance to rust. It is also hoped to study the inheritance of rust resistance.

Safflower (*Carthamus tinctorius L.*).

The original types were maintained. The selfed seeds of the variegated plants (arising out of the unselfed seed of T. 27) were grown and found to breed true. Attempts to cross this variegated plant with the normal green plant of the same type, T. 27, failed.

The F_1 plants of about six crosses between different types were grown and it was observed that the F_1 was intermediate for plant habit (spreading or erect) and maturity, as well as for spininess of leaf and bracts. Red and yellow colour of bud and flower were each dominant to white. A few F_1 plants of each of these crosses have been selfed for the F_2 study.

Sesamum (*Sesamum indicum* D. C.).

The season was unfavourable for this crop and growth was poor. The study of the inheritance of certain characters in a cross between white-seeded and black-seeded types was continued. This cross has also an economic object, *i.e.*, the production of a high-yielding, white-seeded strain. White-seeded types are preferred by the trade as such types yield a lighter-coloured oil than the black-seeded types.

Brassicae.

The study of the self-fertilised types was continued. The report of the Royal Botanical Gardens, Kew, is being awaited to confirm the general classification of the different groups—both self-fertile and self-sterile.

The F_2 generation of the cross (yellow sarson No. 60-1-5× yellow sarson 26-8) was studied for the inheritance of flower colour and the number of pod valves. It was found that the segregation in flower colour is in the ratio of 3 yellow : 1 whitish yellow (creamy colour) and that the ratio of 2-valved pods : 3-4 valved pods is as 3 : 1. There is a good deal of variation in the recessive group but this is to be expected as the parental type with 3-4 valved pods itself shows considerable variation even in the same plant. The theory will be verified next year in F_3.

The inheritance of pod habit was studied in the F_2 generation of a cross between 2 types of *Rai* (*B. juncea* Hooker). The ratio obtained was 3 adpressed : 1 open.

The study of the inheritance of the self-fertility and of seed colour was continued in the following crosses between types of

yellow *sarson* (*B. campestris* var. *sarson*, Prain), a self-fertile group with types belonging to the self- sterile groups :—

1. Black sarson late (*B. campestris L.* var. oleifera Prain) × yellow sarson. F_2.
2. Yellow sarson × Black sarson late. F_3.
3. Yellow sarson × Burma sarson (*B. oleracea* var. chinensis Prain). F_2.
4. Reciprocal of cross 3. F_2.

The inheritance of self-fertility appears to depend upon multiple factors and the study will be continued next year. In seed colour, the blackish red colour of the self-sterile groups appears to depend upon more than 2 factors. This character also requires further study and the difficulties arise mainly because the self-sterile parents cannot breed pure.

Taramira (*Eruca sativa L.*).

An experiment to study sterility was started in 1929-30. The essence of the experiment was to take four pairs of plants such that the individuals of each pair are similar as far as possible. The pairs consisted of the following plants :—

(1) A & B.
(2) C & D.
(3) E & F.
(4) G & H.

A was crossed with B, C with D and so on. Thus four different pedigrees and 8 strains were obtained. In the succeeding years effort was made to keep up these strains as long as possible, pollinating always between A and B and B and A and so on, and never between A and C, etc.

The strains were vigorous and appeared practically uniform in 1930-31. All strains except C × D and D × C, died out as noted below :—

Strains A × B and B × A died out in the year 1931-32, and strains E × F and F × E and G × H and H × G died out in 1932-33.

The strains C × D, D × C appear quite vigorous so far and are quite uniform and will be continued next year.

The above results show that some strains can tolerate close breeding for a longer time than others.

Statement showing the yield of crops in the Botanical Section in 1933-34.

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
Wheat—					
P. 4 .	Inside Musahar 1 (part) . . .	0·20	263·3	1316·5	
P. 4 .	Inside Musahar 2 (part) . . .	0·32	761·1	2378·4	
P. 12 .	Inside Musahar 1 (part) . . .	0·20	372·3	1861·5	
P. 12 .	Inside Musahar 2 (part) . . .	0·32	674·8	2108·8	
P. 12-2	Inside Musahar 1 (part) . . .	0·20	335·3	1676·5	
P. 52 .	Inside Musahar 4 .	0·65	1592·2	2449·5	
P. 101 .	Inside Musahar 3 (part) . . .	0·32	827·0	2584·4	
P. 111 .	Inside Musahar 3 (part) . . .	0·32	765·3	2391·6	
Barley—					
Type 21.	River bank East .	0·76	2746·0	3613·5	Manured with 8 mds.ferm.cakes. Sown late after urid.
,, .	Barah 8 (part) . .	0·25	506·1	2024·4	
Oats—					
B. S. 1	S. T. G. 5 . .	0·16	378·5	2365·6	
Hybrid C	Barah 1 (part) . .	0·05	133·8	2676·0	
,, .	Barah 7 (part) . .	0·14	401·1	2865·0	
Lentil—					
III-54 .	Orchard 1-A . .	0·48	148·1	308·5	Poor germination.
Gram—					
T. 6 .	Pentagonal Border W.	0·13	84·4	649·2	
T. 17 .	Farm Plot 1 . .	1·00	1207·5	1207·5	
T. 17 .	Barah 4 (part) . .	0·182	111·1	610·4	Badly attacked by cut-worm.
T. 25 .	Outside Musahar plots 1, 2, 3 . . .	0·88	1098·5	1248·3	
T. 28 .	Pentagonal Border E.	0·11	168·7	1533·6	
T. 41 .	Barah 4 (part) . .	0·182	156·4	859·3	
T. 58 .	Outside Musahar plots 4 and 5 . .	0·56	629·5	1124·1	
T. 58 .	N. T. G. 10 (part) .	0·11	107·0	972·7	

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
Peas—					
❡ . 14-1 .	S. T. G. 6 . .	0·20	179·0	895·0	
Rahar—					
T. 15 .	½ River side (west) .	0·37	337·4	911·0	
T. 16 .	Pentagonal field .	0·40	389·8	974·5	
T. 24 .	½ River side (west) .	0·37	458·7	1239·7	
T. 41 .	Barah Border (part) .	0·056	94·6	1689·3	
T. 51 .	Orchard 2-D . .	0·71	323·0	454·9	Was damaged badly by hail-storm.
T. 64 .	Pentagonal field (part)	0·21	288·0	1371·4	
T. 69 .	Orchard Border W. (part) . . .	0·036	64·0	1777·8	
T. 80 .	Pentagonal field (part)	0·41	353·8	862·9	
T. 82 .	,, ,, ,, .	0·55	642·8	1168·7	

Statement showing the outturn of improved varieties of crops from the Botanical Section grown on Pusa Farm during 1933-34.

Crop	Plot	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
Gram—				
T 17 . . .	Gonhri . . .	4·00	2972·00	743·00
T 25 . . .	,, . . .	5·00	2832·10	566·42
T 58 . . .	,, . . .	4·00	2236·10	559·03
Linseed—				
T 124 . . .	Old Jhilli . . .	1·50	509·90	334·60
H 10 . . .	,, . . .	0·50	96·70	193·40
H 55 . . .	,, . . .	0·50	67·90	135·80
H 21 . . .	,, . . .	0·50	105·90	211·80
H 68 . . .	,, . . .	0·50	52·40	104·80
T 12 . . .	,, . . .	1·20	454·60	378·83
T 121 . . .	,, . . .	1·00	323·00	323·00
Russian Flax . .	,, . . .	0·30	37·00	123·33
Lentil—				
T 54 . . .	Old Jhilli . . .	1·00	664·50	664·50
T III-86 . .	,, . . .	1·00	695·30	695·30

Crop	Plot	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
Oats—				
Hybrid C	Old Jhilli	2·50	3072·80	1229·12
Hybrid J	,,	2·50	3966·20	1586·48
B. S. II	,,	1·50	2127·10	1418·07
Wheat—				
P 12	Mysore	9·75	11157·70	1144·38
P 52	,,	9·75	13850·70	1420·58
P 4	S. Pangarbi	11·00	5827·30	529·75
P 111	Nepali	11·18	10072·60	900·95
P 101	,,	4·50	4260·40	946·75
Barley—				
T 21	B. F. 1 (30 ac. block)	10·00	11898·60	1189·86
Arhar—				
T 24	H. Jhilli (30 ac. block)	10·00	6697·50	669·75
T 51	,, ,,	10·00	3438·50	343·85
T 15	Chheonia	5·00	3676·10	735·22
T 80	,,	6·75	3761·00	557·19

Miscellaneous.

The results of soil heterogeneity experiments conducted for three consecutive years in the same field at Pusa with barley, wheats and lentils respectively have been embodied in a paper sent for publication in the Indian Journal of Agricultural Science. It was found that there was a great deal of variation in the yields for columns and very little in the rows suggesting that there was a fertility gradient in this particular field which ran from west to east. Harris' method of determining soil heterogeneity and Fisher's analysis of variance method were utilised for this work and it was found that the former method provided only a measure of heterogeneity present in the field while Fisher's analysis of variance not only provided a measure of soil heterogeneity but also clearly set forth the direction of the fertility gradient and is therefore a more comprehensive method for such work.

A knowledge of the amount and direction of variability in the fertility of any experimental field helps in the proper lay-out of yield or manurial trials in the right direction and gives an indication of the shape and size of plot which ought to be employed. The combination which yields the least coefficient of variability within blocks in a preliminary trial is to be taken as the best one for laying out future trials in a field. The results obtained from two uniformity trials conducted in a particular field at Pusa have been employed to illustrate this fact and a paper on this subject has recently been sent in for publication.

III. PUBLICATIONS AND PROGRAMME OF WORK FOR 1934-35.

List of papers sent in for publication during 1933-34.

Bose, R. D.—Some soil-heterogeneity trials at Pusa. *Ind. Jour. Agri. Sci.*

————————Size and shape of plot in field trials. *Ind. Jour. Agri. Sci.*

————————Studies in Indian Barleys. 3. Inheritance of resistance to *Helminthosporium sativum* P. K. and B. in two crosses between Pusa barleys. *Ind. Jour. Agri. Sci.*

————————Studies in Indian Barleys. 4. Branched ears in barley and their mode of inheritance. *Ind. Jour. Agri. Sci.*

Deshpande, R. B.—Studies in Indian chillies. 4 The Inheritance of pungency in *Capsicum annuum L. Ind. Jour. Agri. Sci.*

Kashi Ram and Ch. V. Sarvayya.—The development of pigments in the glumes and apiculus of rice varieties. *Ind. Jour. Agr. Sci.*

————————————————The classification of the rice varieties of Bihar and Orissa. *Ind. Jour. Agri. Sci.*

Khan, A. R. and Akhtar, A. R.—The inheritance of petal colour in gram (*Cicer arietinum L.*) *Agri. and Live-stock in India.* **4,** 1934, 127—155.

Pal, B. P.—Recent Progress in Plant-breeding at Pusa. *Agri. and Live-stock in India.*

Shaw, F. J. F. and Kashi Ram.—Improved varieties of crops produced at Pusa. *Agri. and Live-stock in India.*

Programme of work for 1934-35.

Investigations will be continued on the genetics of those crops which have formed the subject of this report. Special attention will be given to yield trials and statistical methods. Fresh investigations will be started for the improvement of the potato crop and for the isolation of improved strains of sunn-hemp. Training of students will continue as in past years.

(2) REPORT OF THE BOTANICAL SUB-STATION, KARNAL.

(*Financed by the Imperial Council of Agricultural Research.*)

I. INTRODUCTION.

Khan Sahib Abdur Rahman Khan held charge of the Station until his retirement on the 15th December, 1933; his retirement is a great loss to the Section and to the Department. From the 16th of December, 1933, to 11th of April, 1934, Mr. R. B. Ekbote was in charge of the duties of Superintendent in addition to his own. From the 12th April, 1934, Mr. Kashi Ram, Officiating Assistant Economic Botanist, Pusa, took over charge as Officiating Superintendent of the Sub-Station.

In the year under report the following amounts were realized mainly by the sale of the seeds :—

	Rs.	A.	P.
Cash credited into Karnal Treasury . . .	3,581	5	6
Receipts adjusted by Book Transfer . . .	515	7	7
Total .	4,096	13	1

Lay-out and Construction.

To facilitate carting of manure and farm produce a culvert on the road north of the General area was constructed and a certain amount of road levelling was done in the General area. As all the plots in the General area require levelling a block of 18·6 acres has been kept fallow for levelling during the coming cold weather. A threshing floor, bullock lines, and a *bhusa* shed are urgently required.

Training.

The post-graduate students of the Botanical and Agricultural Sections, Pusa, visited this Sub-Station in March 1934, and they studied the following experiments with special reference to the growing of crops under canal irrigated conditions, practically similar to those of the vast areas of the Punjab and the United Provinces but quite unlike those of Pusa where all the crops are grown without irrigation.

(1) The behaviour of Pusa selected *Brassica* types.
(2) Barley yield trials.
(3) Gram yield trials.
(4) Experiments to elucidate the inheritance of characters in gram.
(5) Oat yield trials.
(6) Wheat yield trials.

The students of the Indian Dairy Diploma Course were given lectures on general elementary botany with special reference to agricultural crops.

A batch of students from the Agricultural College, Lyallpur, also visited the Station.

Visits.

B. C. Burt, Esq., C.I.E., M.B.E., I.A.S., Agricultural Expert, Imperial Council of Agricultural Research; Dr. Hudson, Deputy Director, Bureau of Plant-Genetics, Cambridge; Sir Jogender Singh, K.C.I.E., Minister of Agriculture, Punjab and the Director of Agriculture, Punjab, visited this Sub-Station during the year under report.

Season and Rainfall.

During the year under report *Brassica* and gram suffered a good deal from frost. Rains in March favoured the incidence of black rust (*Puccinia graminis*) on wheat so seriously that it reduced the crop yield much below the expectation.

Statement showing the rainfall at the Botanical Sub-Station, Karnal, in 1933-34.

June 1933	5·65	December 1933	0·09
July 1933	9·36	January 1934	1·21
August 1933	6·30	February 1934	0·36
September 1933	17·61	March 1934	1·73
October 1933	0·64	April 1934	0·10
November 1933	..	May 1934	0·20

Total rainfall = 43·25 inches.

II. INVESTIGATIONS.

Wheat.

Some of the new hybrids, between Pusa 4 and Federation and between Pusa 52 and Federation evolved at Pusa, could not attain their maximum development under the non-irrigated conditions and short growing season at Pusa. But when these hybrids were transferred to Karnal they did remarkably well though the types that did best at Pusa gave disappointing results when tried at Karnal. Hence, in order to test adequately the possibilities of the fixed hybrids, it is essential that they should be tested under as many different conditions as possible before they are finally selected or discarded. P. 120 is a hybrid between Pusa 52 and Federation. Its ear-head is compact, fully bearded, smooth glumed with red chaff. P. 165 is a hybrid between Pusa 4 and Federation. Its ear-head is lax, beardless, smooth glumed with white chaff. The hybrids P. 120 and P. 165 along with P. 4 and P. 12 were tested foryield

together with C. 591 and 8A of the Punjab and C. 13 of the United Provinces. The yield trials were carried out both in Latin squares and randomized blocks. The results of one Latin square are given below in detail. Those for the other Latin square and the randomized blocks were very similar.

Varietal Yield Trial.

Wheat.

Comparison of varieties.—P. 165, P. 120, C. 591, C. 13, P. 4, P. 12, Punjab 8A.

Yield of grain in lb. per plot.

P. 120 27·1	P. 165 30·4	C. 591 17·4	8A 14·6	P. 4 13·0	P. 12 7·7	C. 13 10·0
8A 14·4	C. 591 16·1	P. 4 13·4	C. 13 6·6	P. 12 7·3	P. 120 19·6	P. 165 27·1
P. 165 33·4	8A 12·4	C. 13 6·5	P. 12 9·5	C. 591 19·9	P. 4 12·4	P. 120 21·7
C. 591 20·4	C. 13 10·2	P. 120 19·9	P. 4 11·1	8A 9·3	P. 165 27·1	P. 12 7·1
P. 12 11·9	P. 4 15·7	P. 165 27·6	C. 591 14·6	P. 120 22·1	C. 13 9·8	8A 11·8
P. 4 18·2	P. 120 19·9	P. 12 10·0	P. 165 28·9	C. 13 5·9	8A 11·2	C. 591 18·7
C. 13 14·1	P. 12 12·8	8A 12·3	P. 120 19·9	P. 165 29·4	C. 591 16·2	P. 4 15·1

System of replication.—Latin square (7 × 7).

Area of each plot.—15′ × 46′ or 1/63·13 acre.

Summary of results.

	Mean yield in lb.							General mean.	S. E. of treatment mean	Significance of 'Z' test	Critical difference for significance (in lb. per acre)
	P. 165	P. 120	C. 591	C. 13	P. 4	P. 12	Punj. 8A				
Per acre .	1838·8	1354·6	1112·8	568·8	891·8	598·6	776·8	1019·9	44·4	Significant.	172·5 at 1 per cent. level 128·1 at 5 per cent. level
Per cent. on general mean.	180·2	132·7	109·0	55·7	87·4	58·7	76·2	100	4·34		

Conclusions :—P. 165>P. 120>C. 591>P. 4=Punjab 8A>C. 13=P. 12 at 1 per cent. level.

The yield tests for all the above noted wheats were also simultaneously carried out at several Agricultural Stations in collaboration with the Directors of Agriculture of the Punjab and the United Provinces in their respective Provinces. The results from all those places are still awaited.

Besides the two hybrids, *viz.*, P. 120 and P. 165 several other hybrids were also under observation. In order to test their yielding capacity some of the promising ones will be multiplied in the following season.

A large part of the total area of the Sub-Station was under seed multiplication. The demand for pure seed is steadily increasing, and it was not possible to supply more than 25 per cent. of the demand this year. The quantity of seeds distributed from this Sub-Station is shown in a statement at the end of this report.

P. 80-5 on account of its stiff straw did not lodge and remained comparatively free from black rust as well. This wheat was much in demand by the Punjab Agricultural Department.

P. 114 stood remarkably well against the severe incidence of black rust and loose smut.

An experiment in collaboration with the Imperial Mycologist, Pusa, to test the effect of ceresan, copper carbonate, formalin and uspulun (universal) in controlling bunt of wheat was started last November. There were eight replications for each treatment. All the ears in various plots were examined for bunt and the percentage of bunt was determined. The crop was harvested and the number of plants and the number of ears in each plot were counted and the weight of grains taken.

From the results it appears that none of these treatments is altogether effective in controlling the disease though the percentage of diseased ears is reduced. Uspulun (universal) appears to have done comparatively better than other treatments. The only partial success of these treatments is due to the presence of mycelium in the grain. The only fully effective method by which both loose smut and bunt can be controlled is by hot water treatment.

Barley.

An yield trial with five Pusa types together with two types from the Punjab known as L. 4 and L. 5 was laid out and the following results were obtained.

Barley Yield Trial.

Comparison of varieties.—T. 4, T. 13, T. 16, T. 18, T. 21, L. 4, L. 5.

Yield per plot in lb.

L. 5 40·00	L. 4 29·00	T. 18 45·00	T. 16 39·00	T. 21 28·75	T. 13 41·00	T. 4 34·25
T. 18 41·00	L. 5 39·50	T. 4 33·50	T. 13 45·75	T. 16 37·00	L. 4 23·25	T. 21 32·75
T. 16 41·00	T. 18 38·00	L. 4 27·25	T. 21 33·00	T. 4 28·00	L. 5 38·50	T. 13 37·00
T. 13 44·75	T. 16 42·25	T. 21 35·625	L. 4 17·25	T. 18 32·00	T. 4 26·00	L. 5 42·00
T. 4 32·75	T. 21 38·50	L. 5 36·25	T. 18 35·75	T. 13 32·00	T. 16 24·75	L. 4 14·00
T. 21 33·50	T. 4 33·25	T. 13 44·25	L. 5 41·75	L. 4 19·00	T. 18 34·00	T. 16 31·75
L. 4 30·50	T. 13 43·75	T. 16 38·25	T. 4 36·00	L. 5 41·75	T. 21 35·75	T. 18 35·75

System of replication.—Latin square (7 × 7).

Area of each plot.—13′ × 48′ or 1/69·81 acre.

Summary of results

	Mean yields in lb.							General Mean	S. E. of Treatment mean	'Z' test significance	Critical difference (lb. per acre)
	T. 13	L. 5	T. 18	T. 16	T. 21	T. 4	L. 4				
(1) Per acre . .	2877·09	2789·83	2607·81	2533·03	2372·21	2231·37	1598·08	2429·93	87·41	Significant	5 % = 252·36 1 % = 339·88
(2) % on general mean	118·43	114·84	107·35	104·27	97·65	91·85	65·78	100·00	3·60	..	@ 5 % = 10 39. @ 1 % = 13·99.

*Conclusions.*T :—13 = L. 5 > T. 18 = T. 16 = T. 21 > T. 4 > L. 4.

Oats.

An yield trial with 13 hybrids replicated five times in randomized blocks, similar to that of the previous year, was conducted. The results are given below :

Oats Yield Trial

Comparison of types and hybrids (B. S. 1 (M), B. S. 2 (L) and hybrids A-K.)

Yield per plot in pounds.

Varieties Blocks	A	B	C	D	E	F	G	H	I	J	K	L	M
I . . .	16·7500	11·2500	16·1250	16·1875	14·2500	14·3750	14·8750	14·1250	14·8125	15·6875	16·5000	16·5000	16·9375
II . . .	15·2500	11·0625	16·1250	13·4375	14·7500	13·9375	16·0625	12·8125	16·9375	15·7500	13·6250	14·6875	20·8750
III . . .	16·5000	14·1875	17·6875	20·0625	18·3125	18·1250	17·4375	15·7500	17·1250	16·3750	14·9375	18·8750	20·7500
IV . . .	19·0000	13·0000	17·5625	15·3125	20·3750	19·4375	20·0625	16·5000	20·3750	20·7500	16·8750	22·2500	23·7500
V . . .	23·3750	15·7500	24·1250	20·9375	22·1250	22·0625	22·9375	18·0625	21·3750	19·6875	22·5625	19·3750	23·6250

System of replication.– Randomized blocks (13 × 5).
Area of each plot.—60′ × 7′.

Summary of Results

	Mean Yields in lb.													General mean	S. E. of Treatment mean	'Z' test significance	Critical difference (lb. per acre)
	A	B	C	D	E	F	G	H	I	J	K	L	M				
(1) Per acre	1885·01	1353·47	1900·56	1782·59	1862·97	1824·08	1895·38	1602·39	1879·82	1830·56	1752·77	1901·86	2197·45	1820·70	69·72	Significant	@5 % = 193·23 @1 % = 253·95
(2) % on general mean	103·53	74·34	104·39	97·92	102·32	1 0·19	104·10	88·01	103·25	100·54	96·27	104·46	120·69	100·00	3·83		@5 % = 10·61 @1 % = 13·95

Conclusions :—M > A = C = D = E = F = G = I = J = L = K = H > B.

Paddy.

In Upper India generally and especially at Karnal, the so-called autumn paddies are largely grown. The crop is often followed by some *rabi* cereals or legumes. Non-shedding, high yielding, early ripening varieties with thin long-grained rice are much in demand. In order to pick out suitable kinds from the types isolated a preliminary yield test was conducted. This trial resulted in four promising varieties being selected. A proper yield test with these four kinds along with other two types from Pusa will be carried out in the following season.

The isolation of types is practically over now. The characters under study are going to be finally checked in the coming season. The classification of paddy types has been based on qualitative characters, on similar lines to the classification employed at Pusa.

Gram.

Yield trials.—An yield trial with gram Type 17, Type 28, Type 58 and Local was repeated in randomized blocks with 12 replications. The results, however, have shown that the yield differences are not significant. This year gram sowing was delayed due to rains and in January frost did a good deal of damage. The trial, therefore, will be repeated in the course of the next season.

The demand for gram seed this year was considerable and could not be met in full.

Gram crosses.—The inheritance of floral characters has been studied fully and the results have already been published in *Agriculture and Live-stock in India*, Vol. IV, Part II, 1934.

Attention is now concentrated on the study of seed characters such as colour, shape, size and surface, and with this aim in view, the following crosses were grown during the year under report.

(1) T. 35 × T. 2 } F_2 generation.
(2) T. 39 × T. 2 }

(3) T. 39 × T. 2 }
(4) T. 52 × T. 11 }
(5) T. 21 × T. 11 } F_3 generation.
(6) T. 82 × T. 1 }

(7) T. 12 × T. 11 F_4 generation.

Seed colour in gram varies a good deal and some times the range of variability is so wide as to render sorting of phenotypic classes somewhat difficult. While in some crosses inheritance of colour and shape of seed is simple and clear, in others complicated segregation has been observed.

(1) Type 35 × Type 2. In this cross both the parents are white flowered. Type 35, however, has orange coloured and perfectly

round seeds and Type 2 has white and less round seeds. F_1 seeds were intermediate between orange and white, more like Type 2 and round like the Type 35 parent. In F_2 a ratio of 2 intermediate : 1 white like Type 2 has been realised. Seed shape inheritance, however, seems to be less simple. It was observed that round seeds like Type 2 formed 9/16th and those like Type 35, 7/16th of the total. The results will be confirmed in F_3 which will be grown next year.

(2) Type 39 × Type 2. In this cross parent Type 39 has pink flowers while Type 2 is white flowered. In F_1 the flower colour was pink and in F_2 a ratio of 3 pinks : 1 white was observed. As regards seed, Type 39 is yellowish pink and irregular while seeds of Type 2 are white and somewhat round. F_1 seeds were more or less like Type 39 in colour and irregular in shape. In F_2, besides the seeds of parental types and those like F_1, new forms such as deep red, orange and fawn have appeared. It seems that the seed colour in this cross is determined by more than two factors.

(3) Type 82 × Type 1. As in the above cross, the F_2 results indicated a trihybrid segregation. The F_3 is being studied at present.

(4) Type 52 × Type 11. All crosses with Type 11 have given clear segregations and the F_3 observations have borne out the F_2 results. Type 52 is pink flowered with yellowish brown and irregular seeds. Type 11 has white flowers and bluish brown and round seeds. In F_1 the flower colour was pink and seeds were yellowish brown and irregular like the Type 52 parent. In F_2 the following segregation as regards seed colour and shape was observed :—

	Observed	Expected on 3 : 1 ratio.
Yellowish brown irregular . . .	39	41·25
Bluish brown round	16	13·75
Total .	55	55·00

$\frac{\text{Dev.}}{\text{P. E.}} = 1{\cdot}04$

Fit is good.

It is thus evident that yellowish brown colour and irregular shape are dominant over bluish brown and round seeds and that a one factor difference is responsible.

It will, however, be interesting to consider seed colour and shape in relation to flower colour. In F_2 a ratio of 9 pink : 3 blue : 4 white flowered plants was observed.

Flower colour	Pink	Blue	White.	
Seed colour	Yellowish brown.	Bluish brown.	Yellowish brown.	Bluish brown.
Seed shape	Irregular	Round	Irregular	Round.
Observed	31	12	8	4
Expected on 9 : 3 : 3 : 1 ratio	30·93	10·31	10·31	3·44

$X^2 = 0·8995$
Fit is good.

The observations in F_3 confirm the above results. It will thus be seen that all pink flowered plants produce yellowish brown and irregular seeds, blue, bluish brown round seeds, while in white flowered plants one-third produce bluish brown round seeds and two-thirds yellowish brown and irregular seeds. The factors responsible for flower colours also influence seed colour and shape. It is assumed that factor B is responsible for blue colour in flower and bluish brown round seeds. Factor A has a similar action on seed like B but does not influence flower colour. Factor P modifies blue flower colour to pink and bluish brown and round seeds to yellowish brown and irregular. Type 11 has only A, since its flower is white and seeds are bluish brown round. Parent Type 52 has all the three factors, *viz.*, A, B and P. P and B being present the flower is pink and seeds yellowish brown and irregular. In F_2 factors B and P segregate and give the ratio mentioned above.

(5) Type 21 × Type 11. The results of this cross too are clear though one factor in addition to the three described above has been found to interact. As regards flower colour the results are exactly similar to cross Type 52 × Type 11. Type 21 has dark reddish brown seeds and when crossed with Type 11 gave in F_1 dark reddish brown seeds and in F_2 a ratio of 9 dark reddish brown to 3 yellowish brown to 4 bluish brown seeds. The relation of flower colour to seed colour observed in cross Type 52 × Type 11 holds good All pink flowered plants give 27 dark reddish brown : 9 yellowish brown seeds, all white flowered plants 9 dark reddish brown : 3 bluish browns : 4 yellowish brown seeds ; and all blue flowered plants possess only the bluish brown and round seeds. The segregation is trihybrid and can be explained on the assumption that in addition to factors A, B, P, Type 21 has a factor D which modifies yellowish brown seed to dark reddish brown.

(6) Type 12 × Type 11. This cross has presented the least difficulty. Both the parents are white-flowered. Type 12 has

reddish brown irregular seeds. In F_1 the seeds were somewhat reddish brown and in F_2 a simple ratio of 3 reddish brown irregular : 1 bluish brown round seeds was realised. The F_2 behaviour was subsequently confirmed in F_3 generation.

In addition to colour and shape of seeds, seed surface and presence and absence of black dots on seed coat were also studied and both behave as mendelian characters. The detailed results of all these characters will be submitted for publication later.

Brassica.

Cultures.—Many cultures representing different species of Brassica were grown and observations on the morphological characters as a step to classification have been taken and compared with those recorded in the previous year. Specimens of these cultures were sent to Kew gardens by the Imperial Economic Botanist, Pusa, for identification. A provisional identification has been done but the enquiry will be complete only after examining fresh material which is being raised from seeds sent from Pusa.

Crosses.—The inheritance of seed colour, self-fertility and root thickness was studied. The details are given below :—

(1) *Cross.*—Yellow sarson 75-1 × Toria 48-1 F_2.

Number of F_1 plant	Red seeds	Yellow seeds	Total
1	37	16	53
3	25	9	34
4	26	20	46
Total observed	88	45	133
Expected on 3 : 1 ratio	99·75	33·25	
$\frac{\text{Dev.}}{\text{P. E.}} = 3·49$			
Fit is bad.			

(2) *Cross.*—Toria 48-1 × Yellow sarson 60-1-5 F_2.

Number of F_1 plants	Red seeds	Yellow seeds	Total
1	6	2	8
2	18	6	24
3	13	2	15
4	23	5	28
5	12	1	13
Total observed	72	16	88
Expected on 3 : 1 ratio	66	22	88

$\frac{\text{Dev.}}{\text{P. E.}} = 2{\cdot}2$

Fit is good.

(3) *Cross.*—Yellow sarson × Black sarson F_2.

No. of F_1 plan	Red seeds	Yellow seeds	Total
1	10	1	11
2A	26	7	33
2B	57	15	72
3	4	0	4
5	18	2	20
7A	2	2	4
7B	16	9	25
12	22	2	24
22	21	5	26
Total observed	176	43	219
Total expected	164·25	54·75	

$\frac{\text{Dev.}}{\text{P. E.}} = 2{\cdot}7$

Fit is good.

It will be seen that the frequency of the yellow seeded phenotype is in excess in cross No. 1 while in the rest it falls below the expected numbers. The population is limited due to heavy casualties as a result of frost and hence if seed colour is controlled by more than one factor, chances of realising the recessive phenotype, *viz.*, the yellow seeded class are reduced.

The inheritance of root thickness was studied in a cross, Turnip × Yellow sarson 60-1-5. Yellow sarson has a thin tap root while

turnip root is bulging. The F_1 root was intermediate in thickness. In F_2 the following segregation was observed :—

F_1 plant number	Root like turnip	Root inter-mediate	Root like yellow sarson	Total
1	5	38	19	62
4	21	135	55	211
Total observed .	199		74	243
Expected on 3 : 1 ratio . .	204·75		68·25	243

$\frac{\text{Dev.}}{\text{P. E.}} = 1 \cdot 2$

The fit is good.

During the course of study it was easier to distinguish roots like yellow sarson than those like turnips from intermediates. Hence the frequency of sarson-like roots is considered against the total of intermediate and turnip-like roots.

Inheritance of self-fertility.

It was intended to study the inheritance of this character in a large population and with this aim in view 400 plants were bagged in all. The season was, however, most unfavourable for study of this character. Due to heavy frost, setting of seed even outside the selfing bags was greatly hampered. The result was that out of the population of 400 only a small number of plants could be studied.

The results though incomplete suggest that a unit factor is responsible for the difference and that self-fertility is dominant.

III. SEED DISTRIBUTION.

The following statement shows the quantity of seeds distributed during the year 1933-34 :—

Crop	Quantity of seed distributed in lb.	Total
Wheat Pusa 4	12194·8	
,, ,, 12	8640·0	
,, ,, 80-5	13381·7	
,, ,, 111.	1902·9	
,, ,, 112.	617·1	
,, ,, 113.	658·3	
,, ,, 114.	1306·3	
,, ,, 120.	2320·5	
,, ,, 165.	1435·9	
		42457·5
Gram Type 17	3702·9	
,, ,, 58	3250·2	
		6953·1

IV. YIELDS OF CROPS.

Statement showing the crop returns of the Botanical Sub-Station at Karnal for 1933-34.

Area	Plot No.	Crop	Area in acres	Actual yield in lb.	Calculated outturn per acre in lb.	Bushel weight in lb.
General—	29—34	Gram T. 17	8·33	11637·3	1397·03	
	28	T. 28	1·84	2797·7	1520·49	
	24—27	T. 58	8·54	16794·6	1966·58	
	35—41	Wheat P. 4	15·50	10806·2	697·17	56·2
	44—51	P. 12	12·58	7656·7	608·64	52·0
	17—23	P. 80—5	16·47	16560·1	1005·47	64·8
	6—13	P. 111	9·71	7191·8	740·66	64·8
	14	P. 112	1·37	968·9	707·23	64·7
	15	P. 113	1·41	1082·1	767·45	64·1
	1—5	P. 114	4·63	5091·4	1099·65	64·9
	42	Oats Hy. J	3·18	5136·7	1615·31	29·6
	43	B. S. 1	1·0	1656·0	1656·0	31·7
Experimental—	15—16	Wheat P. 120	2·55	4198·7	1646·55	61·20
	13—14	P. 165	2·26	4754·1	2103·60	63·86
Rice .	3 a	Paddy A	·30	432	1440	
		B	·33	432	1309	
		C	·32	310	969	
		D	·33	308	933	
		E	·32	370	1156	
		F	·32	473	1478	
		G	·32	372	1162	
		H	·43	391	909	
		J	·27	247	915	
		K	·24	175	729	
		L	·52	376	723	
		M	·26	144	554	
Building .	1	Toria local	·41	730	1780	

REPORT OF THE SUGARCANE EXPERT.

(Rao Bahadur T. S. Venkatraman, B.A., I.A.S.)

I. CHARGE AND STAFF

I held charge of the office of the Government Sugarcane Expert throughout the year except for one month's absence on leave in September 1933, when the Second Cane Breeding Officer, Mr. N. L. Dutt, M.Sc., held charge. The Second Cane Breeding Officer was absent on leave till 3rd August 1933 and during the period Mr. M. K. Krishnaswami, M.A., his senior Assistant, held charge of duties of Second Cane Breeding Officer in addition to his own. Mr. G. V. James continued to be in charge of the Sub-station at Karnal throughout the year.

With the help of funds kindly sanctioned by the Imperial Council of Agricultural Research, the staff at the Station was strengthened by the appointment of a Sugarcane Geneticist and Dr. Miss E. K. Janaki-Ammal, M.A., M.Sc., D.Sc., F.L.S., joined the post on the 25th May 1934.

II. SUGARCANE BREEDING (MAINLY SUB-TROPICAL TYPES)

(*a*) Breeding technique

(*i*) *Controlling time of arrowing.*—The planting of canes at different seasons and under different soil conditions synchronised their times of arrowing to such an extent as to enable effecting of crosses not possible hitherto. A modified form of topping—concentrating on the side shoots—was started with the object of further influencing time of arrowing.

(*ii*) *Isolation of arrowing canes.*—The Coimbatore method of isolation of arrowing sugarcanes in tile pots for purposes of hybridization—which had proved so useful in the past—was further simplified by Mr. R. Thomas, who obtained equally good results by isolating the canes in water culture and in earthen pots.

(*b*) The Breeding programme

The arrowing during the season was normal and satisfactory; and this enabled the carrying out of the programme laid down for the year more or less fully, so far as the breeding of economic types was concerned. Certain of the trial crosses had, however, to be postponed owing to the disparity in the times of arrowing of the parents, which had not been specially planted for the purpose.

The economic bulk crosses included six combinations, three of them being made for supplying seedlings as seedlings to the Substation at Karnal and the Sugarcane Research Station at Shahjahanpur. The parents employed in these bulk crosses were mostly Coimbatore canes of proved utility such as Co.'s 213, 244, 281, 285, 290 and 313. Six trial combinations were made to pick out the most promising of them for the bulk crossing of economic type during subsequent years. Nine combinations—involving types of *Saccharum spontaneum* or *Sorghum*—were effected in connection with cytological studies of the genus *Saccharum*. During the season about a lakh and a half of seedlings were raised of which about half were planted in the first ground nurseries. These were thinned down to about 18,000 while planting in the second ground nurseries for a full year study.

(*c*) New Parents

Certain of the hybrids between P. O. J. 2725 and various types of *S. spontaneum*—originally raised for academic studies—showed distinct promise of use as parents on account of their health and good tillering power. These were, therefore, added to the plot of parents at the station. Other new parents thus added during the year included three of the hybrids between P. O. J. 2725 and *Sorghum Durra* Stapf raised in the year 1930. These hybrids, which showed little healthy pollen in the first year, are now producing a fair amount of such pollen and setting seed freely as well. As the resultant seedlings showed satisfactory vegetative and juice characters the above hybrids have also been added to the collection of parents.

(*d*) Selection of useful types

Of the 126 seedlings under test in rows during the year seventeen were raised to the status of Co.'s on data obtained from periodic root and shoot studies and juice analysis. These studies have revealed interesting differences between varieties in the manner by which the tonnage at harvest is built up during the different stages of growth. Whereas in certain cases the full growth of cane is laid fairly early in the ripening season, in others the process would appear to be continuous during the ripening period. The selections include five 'early', three 'medium' and nine 'late' maturing types. The outstanding 'early' types include one seedling obtained by selfing Co. 214 which is itself an early maturing cane; the second is a hybrid between P. O. J. 2725 and *Sorghum Durra* Stapf.

III. RESEARCH AND INVESTIGATIONS.

(*a*) *Studies in germination.*—Quick and vigorous germination being a most desirable character in a new cane, work was started

by the Assistant Sugarcane Expert, Mr. K. Krishnamurthi Rao, on possible correlations and devising means to improve germination in the field. Promising results have been obtained both from topping canes in the field and soaking the setts previous to planting. The data obtained confirm the previous finding at the station that, in a three budded sett, the central one germinates the quickest and the best.

(*b*) *Effect of arrowing on juice quality.*—Periodic juice analyses of arrowing canes by Mr. K. V. Gopala Iyer, B.A., showed that improvement in both sucrose and purity is possible long after the arrows are out—as much as two months in certain cases. While it is true that in the same field the arrowed canes show slightly higher sucroses and purities than non-arrowed ones, the arrowing by itself is not a sign of cane maturity.

(*c*) *Cytological studies.*—A certain amount of new ground in sugarcane cytology was covered during the year through the enthusiastic work of Mr. T. S. N. Singh, B.Sc., largely on material carefully preserved and planted from year to year for over a decade by Mr. R. Thomas. Chromosome countings were made not only of the different types of *S. spontaneum* and of *Saccharum munja* but also of the various inter-specific and intergeneric hybrids available at the station. Certain of the results obtained and since published have been confirmed by a recent publication by Dr. G. Bremer till recently and for long the cytologist at the Sugarcane Experiment Station at Pasoeroean in Java. The *Sorghum* hybrids would appear to contain at least two groups—one in which there is a doubling of chromosomes on the mother side at *Karyokinesis* and the other where there is no such doubling.

(*d*) *Saccharum spontaneum types.*—A tour in Bihar by Mr. R. Thomas with the active help and full co-operation of the Bihar Department of Agriculture—through Mr. D. R. Sethi, the Director and Mr. K. L. Khanna, the Sugarcane Specialist—has resulted in the addition of eight new types to the collection of *S. spontaneums* at the station. One hundred seedlings from most of the types are growing in the plots for morphological and cytological studies. A form from Burma is easily outstanding on account of its great tillering power, but its arrowing is neither steady nor abundant.

(*e*) *Soil types to suit different canes.*—A cheap and simple method was devised to get indications about the kind of soil best suited to particular canes. Briefly stated the method consists in growing the plants above and away from the soil by an arrangement previously evolved at the Station and developing a definite number of shoot roots from a node well abode the soil level. An equal number of these roots are now made to grow and develop in different pots each containing one of the soils under test. Data thus obtained have largely corroborated the recorded experience with different

canes ; and Mr. S. A. Hussainy has made himself responsible for an extensive study on these lines.

(*f*) *Sugarcane-Sorghum hybrids*.—The rather extensive series of these crosses between Sugarcanes and *Sorghum* mentioned in the last report yielded a certain number of selections, some of which were characterized by high sucrose and purity percentages. The combinations with Coimbatore canes gave, on the whole, better types than that with P. O. J. 2725.

F_1 hybrids between P. O. J. 2725 and *Sorghum Durra* Stapf crossed with the *Sorghum* male parent, yielded a rather interesting series. Besides plants which showed very obvious traces of the *Sorghum* parent, the series included certain peculiar types which showed rather continuous flowering and thick coriaceous leaves very dissimilar to those of either Sugarcane or *Sorghum*. (Plate II, fig. 1.)

IV. RESEARCH AND INVESTIGATIONS BEARING MAINLY ON THICK CANE BREEDING

(N. L. Dutt, M.Sc.)

(*a*) Breeding.

An important feature of the hybridization programme during the year was the further utilization of certain of the hardier medium Coimbatore canes as one of the parents, *viz.*, Co. 205, Co. 243, Co. 244, Co. 285 and Co. 290. This was done because canes like Co. 402, Co. 408, Co. 413, Co. 417 and Co. 419—which contain the blood of the hardier types—are proving a success in the preliminary trials at the various Experiment Stations in India. The following crosses were, therefore, made on a bulk scale :—

(1) *Vellali* × Co. 243, (2) P. O. J. 2725 × Co. 243, (3) P. O. J. 2878 × Co. 290. Other combinations which are expected to yield good seedlings are Co. 419 × Co. 244 and Co. 411 × Co. 243.

One of the problems in the breeding of the tropical types for India has been to breed varieties that will resist wind and cyclones. Some success was obtained in this direction as the majority of the seedlings in the cross Co. 408 × Co. 415 have the needed habit with short erect canes. (Plate II, fig. 2.)

(*b*) Selection

The selection of suitable thick type of canes has now reached an important stage as the satisfactory growth of recent distributions has enabled the setting up of standard types for the various tracts. Accordingly 15,000 seedlings, which had been raised from seed, and had completed their full growth in the field were studied and 210 of them as conformed to the standard types in growth and

PLATE II.

Fig. 1. One of the many curious types obtained from the combination (P. O. J. 2725 X *Sorghum Durra* Stapf) X *Sorghum* Durra Stapf. The plants are much stunted in growth and possess short thick coriaceous leaves very dissimilar to those of either the sugarcane or Sorghum parent.

Fig. 2. The cross Co. 408 X Co. 415 yields seedlings with short erect canes a type likely to be useful in the breeding of canes to resist wind and cyclones. The above shows a plot of seedlings from this combination.

sucrose percentage were selected for further testing. Similarly eleven seedlings from the final test plots were selected after comparing their yields with the standards and were raised to the status of Co.'s during the year. Their parentages are given elsewhere in the report.

(c) Characteristics of certain thick cane seedlings

It is proposed to study definite characteristics of such thick cane seedlings as show promising growth in various Experiment Stations During the year observations were, therefore, made on the late. ripening quality of Co. 402. This cane is a fairly heavy yielder and is at the same time relatively non-flowering. It is unimpressive in the early stages of its growth, but pulls up later and finisher as a good yielder. It is, however, a full eleven to twelve months cane and capable of standing in the field without significant deterioration upto thirteen to fourteen months. Rao Sahib B. P. Vagholkar, Principal Agricultural Officer, Padegaon Sugarcane Research Station (Bombay Presidency), reports that this cane has done "exceptionally well". It is, therefore, likely to find favour for making jaggery with such ryots as are accustomed to growing green or yellow coloured noble canes like *Pundia*, *Poovan* or *Vellai*, while for factories its chief attraction will be that it can be crushed late. The following table gives analyses of a few rows of this variety which were left over un-harvested after the fourteenth month.

Table I

Fortnightly analyses of Co. 402 from the fourteenth month onwards in Field No. 7. (Planted on 12th February 1933)

Date of analyses	Brix Per cent.	Sucrose Per cent.	Co-efficient of purity
5th April 1934 . . .	17·60	15·49	88·0
20th April 1934 . . .	17·55	15·46	88·1
5th May 1934	15·57	13·54	87·0
21st May 1934 . . .	14·49	12·57	88·4
5th June 1934	16·44	14·06	85·5

(d) Morphological study of thick canes

Some attention was devoted to the study of morphological characters of thirty varieties of the noble or thick type grown in India. These have been tentatively assigned to various groups and a few points still remain to be cleared up. These have been planted according to groups to facilitate observations *en masse*.

(*e*) Cytological studies

Botany Assistant, Mr. K. S. Subba Rao, B.A., continued his studies on chromosomes in noble canes as also on fertilization and embryogeny with interesting results.

Mr. Rao has investigated six more varieties including *Kaludai Boothan*, *Striped Mauritius*, and *Badila* (*Fiji B*). He has also fixed material for the study of the morphology of chromosomes, a necessary complement to the study of morphological characters of varieties.

Further progress was made with regard to fertilization studies. In the cross P. O. J. 2725 × *Glagah*, a sperm nucleus was noticed near the egg nucleus five hours after pollination. This shortens the time taken by the pollen tube to reach the embryo-sac by about two hours from the previous record of seven hours. Sugarcane varieties differ in the rate of growth of their pollen tubes in artificial culture and the time taken by the pollen tubes to reach the embryo-sac probably varies with the pollinating parent.

During the course of the study of embroygeny a few cases of the abnormal position of the egg were noticed. In one of the preparations the egg was near the antipodals, while in another two eggs were noticed, one at each end of the embryo-sac.

A case of polyembryony has already been recorded in one of the previous reports. That was noticed in one of the microtome sections and attempts have since been made to see whether the same phenomenon occurs in the actual germination of seeds. In the seeds collected from the cross Co. 400 × Co. 205 two independent plumules and radicles were noticed coming from one and the same seed.

(*f*) Controlling time of arrowing

Canes of Co. 290 were subjected to six hours day light. These flowered twenty-six days earlier than the controls. The pollen, however, gave only one per cent. germination when cultured artificially.

The experiment on " Topping " was conducted on a somewhat larger scale than in previous years. Canes of P. O. J. 2878 were ' topped ' twice and flowered eleven days later than the controls. This enabled their crossing on a bulk scale with Co. 290. The germination of the seeds was satisfactory.

(*g*) Pollen studies

An interesting observation made during the course of the pollen studies was that in the artificial cultures the pollen grains in crowded portions germinated much better than where the grains were scattered, indicating some effect of massing.

In working with a crop like sugarcane the principle operations such as crossing, study of flowering habits, pollen viability, etc., have to be crowded in in a period of about two months, and when for a single item like pollen germination, over 300 cultures have to be gone through, any method which will help in taking up the cultures at leisure will be an advantage. Unless the cultures are examined on the same day or at the utmost on the next day, fungal growths appear and besides, the contents of the burst tubes and grains render the making of observations a difficult task. Botany Assistant, Mr. M. K. Krishnaswamy, M.A., has devised a method by which the cultures in petri dishes can be examined even after about a fortnight. He tried form-acetic-alcohol but with not much success, as dessication and consequent bursting of grains and tubes set in. If, however, a few drops of formalin are added to the bottom dish it keeps the pollen tubes intact and also prevents growth of fungi.

(*h*) Germination in thick cane seeds

Experiments were continued on the comparison of *Vellai* with two of its seedlings, *viz.*, Co. 400 and Co. 403 for seed germination when the same pollinating parent was employed. Equally weighed quantities—three grms. per seed pan—were sown. The parentage of Co. 400 is *Vellai* × Q. 813 and of Co. 403 is *Vellai* × Co. 243. The male parents used were E. K. 28 and Co. 205. The germinations obtained are given in Table II.

Table II

Germination per pan

	10 days	20 days	30 days
Vellai × E. K. 28 . . .	239	175	122
„ × Co. 205 . . .	14	12	12
Co. 400 × E. K. 28 . .	749	718	661
„ × Co. 205. . .	789	675	597
Co. 403 × E. K. 28 . .	39	49	55
„ × Co. 205. . .	72	114	112

It will be seen from the above that the largest number of germinations were obtained when Co. 400 was employed as the ovule parent.

In order to ascertain if there is any correlation between size and germination capacity, measurements of seeds were taken in the varieties, *S. spontaneum*, *Glagah*, *Saretha*, Co. 205, *Vellai* and

Kaludai Boothan. The following table gives their comparative sizes. It is proposed next year to find out the comparative weights also.

TABLE III

Size of seeds in different species of Saccharum

Name of the variety	Length and thickness in microns	Average of
		Seeds
S. spontaneum	1192·95 × 461·45	100
Glagah	1416·25 × 555·50	129
Saretha	1301·02 × 569·25	100
Co. 205	1574·37 × 523·05	100
Vellai	1787·50 × 607·95	103
Kaludai Boothan	1561·17 × 582·17	100

V. DISTRIBUTIONS FROM THE STATION

(*a*) As true seed

Seeds obtained by crossing P. O. J. 2725 with hardy Coimbatore canes like Co. 243 and Co. 244 were sent to the Director of Plant Breeding, Sydney, Australia, on request. The object of this importation by the recipient country is to secure canes resistant to both frost and diseases. Previous consignments sent to Australia are reported to have yielded promising types.

(*b*) As seedlings

Five thousand seedlings of Co. 213 crossed with Co. 285 and Co. 244 were sent to the Sub-station at Karnal and an equal number of Co. 290 × Co. 281 to the Sugarcane Research Station at Shahjahanpur. Both the above schemes are financed by the Imperial Council of Agricultural Research and the above sendlings are for exploring the possibilities of selecting and rejecting new seedlings in sub-tropical India even in the nursery stage

(*c*) As canes

Over 200 packets containing sixty varieties, mostly Co.'s, were distributed to over thirty places within Indian limits. The foreign sendings consisting of twenty-one packets were sent to Abyssinia, Leningrad, Washington, Formosa, Sydney and Kenya.

VI. PERFORMANCE OF COIMBATORE CANES

(*a*) Coimbatore canes in Sub-tropical India

A rather pleasant surprise during the year was the manner in which Co. 223 was working its way in the Kangra District of the Himalayas and at altitudes of over 4,000 feet above sea level. With the cheap water power available in the tract, there would appear to exist distinct possibilities in the future. This discovery is due to the enthusiasm of Khan Bahadur Fateh-ud-din, Officiating Director of Agriculture, Punjab, whose co-operation with the work of Coimbatore has been both long and continuous.

The types mentioned as promising in the previous report are continuing to hold their own, Co. 313 and Co. 331 being rather outstanding. Co. 349 and the Sugarcane × *Sorghum* hybrid Co. 356 would appear to be among the canes of the future. The area under the improved canes—which is steadily becoming synonymous with Coimbatore canes—touched fifty per cent. during 1932-33. These canes are primarily responsible for increasing the average acre tonnage for the whole of India from eleven to fifteen tons.

(*b*) Coimbatore canes in Tropical India

The new series bred at the thick cane area by Mr. Nand Lall Dutt, M.Sc., has begun to attract attention in most farms both in North and South India. Co. 361 in North-West Frontier Province, Co. 408 at Karnal (Punjab), Co. 413 at Shahjahanpur (United Provinces), Co's. 361 and 407 at Jorhat (Assam) and Co's. 360 and 402 at Padegaon (Bombay Presidency) are at present heading this batch of Coimbatore thick types.

Co. 213, Co. 281 and Co. 290 continue to be popular over certain areas in tropical India, the first named being the most sought for for covering new or indifferent lands. Co. 243 and Co. 313 are the new medium canes of promise in the Anakapalle tract of the Madras Presidency while Co. 290 has found a definite place in parts of the Bombay Presidency under comparatively adverse conditions of soil and irrigation.

(*c*) Coimbatore canes in foreign countries

Co. 281 and Co. 290 followed by Co. 213 are proving useful in foreign countries like Argentina, Louisiana, South Africa and Australia. The former two would appear to have revealed un-suspected resources of both drought and disease resistance, out-rivalling a cane of even such outstanding merit in this direction as Uba.

(*d*) Sugarcane-*Sorghum* hybrids

These have been growing in sub-tropical India now for the last two seasons. Though it is perhaps too soon to judge, the indication exists that in sub-tropical India they may not show fitness for milling in six to seven months as at Coimbatore. This might be due either to the employment of the Coimbatore type of *Sorghum* in the first hybridization or to the fact that the crop in sub-tropical India is faced with heavy rains six to seven months from planting. In tonnage and other characters some of these *Sorghum* hybrids (in North India) are hardly distinguishable from the interspecific hybrids now spreading in the tract. One of these—Co. 356—has shown promise of usefulness in more than one North Indian Station. From available information it would appear that certain of them—though not fit for milling in six or seven months as at Coimbatore—might yet be the earliest to mature during the ripening period for canes in the area.

In tropical India the most extensive tests with these hybrids have been in the Madras Presidency where they have been planted and analysed almost month-war. The first year results have been published and it has been found that certain of them attain "a purity of 85 and over in about 200 to 220 days from the time of planting and tend to improve in quality for nearly 100 days afterwards". "The juices of *Sorghum* hybrids at the point of their maximum efficiency were decidedly richer than those of other Coimbatore canes." (Viswanath, B., 1934, *Ind. J. Agric. Sci.* **4**, 215.)

VII. THE KARNAL SUB-STATION

(*a*) Programme of work

The two years' experience, from growing seedlings at Karnal in different ways and planting them in the ground at different times of the year, has given indications about the most effective manner in which to carry on the work programmed for the Sub-station. The best method would appear to consist in effecting the desired crosses at Coimbatore right at the beginning of the arrowing season, sow them in pans at Coimbatore almost immediately after collection, transport the young seedlings to Karnal in a through railway wagon (the seedlings being carefully hardened for the journey) and plant them in the lands at Karnal at the usual planting time for canes in tract. Thus handled, the seedlings show normal growth and allow preliminary selections being made at the end of their first year at Karnal. It is proposed to pursue this method till further experience definitely indicates a better one.

(*b*) Sugarcane studies

(*i*) *Shoot and root studies.*—Results of periodic shoot and root studies were not so effective owing to the absence of a pronounced summer during the year. In a testing station an unfavourable year is of distinct use as it enables the picking out of types that can stand adverse conditions.

(*ii*) *Juice quality.*—Periodic hand refractometer readings started in August 1933 and continued till February 1934 gave useful information not only on the time of maturity of the different types but also the period during which the different canes maintain their juice quality without serious deterioration ; the latter is an important character in cane cultivation, whatever be the nature of the end product, *gur*, *rab* or white sugar.

(*c*) Selection

Of the over 5,000 seedlings grown as seedlings at Karnal, 126 showed sufficient promise for trial in rows. Of the 121 seedlings grown in rows and originally obtained from Coimbatore as cuttings most of them grown at Karnal for two seasons—forty-two were selected for further trial at Karnal and in certain of the Punjab farms. At the end of the year there were 180 new seedlings in row tests besides the 5,000 transported from Coimbatore as seedlings.

(*d*) Distributions

Material of the different canes growing at Karnal and consequently, partially acclimatized to sub-tropical conditions, were supplied to the two Sugarcane Research Stations in the Punjab financed by the Imperial Council of Agricultural Research. Material thus supplied exceeded a thousand maunds and included nearly 100 types.

Among material thus distributed mention needs to be made of three canes which were originally obtained from seed collected at Coimbatore and germinated at Karnal. These are early ripeners and should give valuable indications about the future line of work at Karnal. These have been distributed to the Sugarcane Research Station at Shahjahanpur as well, at the desire of the Honourable the Minister for Agriculture in the Punjab.

VIII. PARENTAGE OF COIMBATORE SEEDLINGS

Parentages of seedlings raised to the status of Co.'s during the year are given in Table IV.

TABLE IV

Parentage of Co. canes

Seedling No.	Parentage
Thick Types—	
Co. 421	P. O. J. 2878 × B. 3412.
Co. 422	P. O. J. 2878 × Co. 214.
Co. 423	P. O. J. 2878 × Co. 364.
Co. 424	Kassoer G. C. (likely father Ges. Preanger).
Co. 425	P. O. J. 2727 × P. O. J. 2878.
Co. 426	(Vellai × P. O. J. 1410) × Co. 360.
Co. 427	(Vellai × P. O. J. 1410) × (Kassoer × Badila).
Co. 428	P. O. J. 2725 × Co. 290.
Co. 429	Co. 402 × P. O. J. 2878.
Co. 430	Co. 407 × E. K. 28.
Co. 431	Co. 363 × C. A. C. 87.
Medium Types—	
Co. 500, Co. 501	Co. 221 × Co. 229.
Co. 502	Co. 243 × Co. 244.
Co. 503	Co. 317 selfed.
Co. 504, Co. 505, Co. 506, Co. 507, Co. 508, Co. 509	Co. 214 selfed.
Co. 510, Co. 511, Co. 512	Co. 213 × Co. 244.
Co. 513, Co. 514	Co. 213 G. C.
Co. 515, Co. 516	P. O. J. 2725 × *Sorghum Durra* Stapf.

IX. STUDENTS UNDER TRAINING

Two post-graduate students, who joined the station in November 1932, finished their first year at Coimbatore and left for Pusa to do the second year training there. Post-graduate student, Mr. Imdad Ali Khan, joined the Station on 1st December 1933 after completing his first year course at Pusa.

X. MISCELLANEOUS

The study of *S. spontaneums* at Coimbatore carried on under the auspices of the Madras University was completed during the year and the results published in the *Indian Journal of Agricultural Science.*

The sixth meeting of the Sugar Committee appointed by the Imperial Council of Agricultural Research was held at the station 14th to 16th November 1933. This gave a much desired opportunity to the members of the Committee to get first-hand knowledge of the work of the station.

The visitors during the year included Dewan Bahadur Sir T. Vijayaraghavacharya, K.B.E., Chairman, and members of the Sugar Committee, Dr. C. D. Darlington of the John Innes Horticultural Institution, Merton, Dr. P. S. Hudson, Deputy Director, Imperial Bureau of Plant Genetics, Cambridge, Mr. Ebrahim Mahdavy, Officer in charge of the Government Experiment Stations, Iran, and Mr. G. M. Schuitenmaker, Representative of the N. I. V. A. S., Java.

XI. PROGRAMME OF WORK FOR 1934-35

Major

The breeding of medium and thick canes will be carried on with the object of effecting further improvements, covering new tracts or cheapening cost of cultivation.

Attempts will be made to further improve the breeding technique and secure better germination with thick cane seeds.

Studies on the genetics of the sugarcane and of the genus *Saccharum* will be continued and extended.

Minor

Morphological studies of the thick canes, studies of fertilization and embryogeny and of morphology of chromosomes will be pursued as also of sugarcane roots and of pollen and seed viability.

XII. PUBLICATIONS

(1) Dutt, N. L. and Krishnaswami, M. K. — The Breeding of the Thick Type of Canes for India. *Madras Agric. Jour.*, Vol. XXII, No. 3, March 1934.

(2) Dutt, N. L. and Subba Rao, K. S. — A Preliminary Note on the Membraneous Body in the Cytoplasm as characteristic of the Indigenous Indian Canes. *Ind. Jour. Agric. Sci.*, Vol. IV, Pt. I, February 1934.

(3) Singh, T. S. N. . . Chromosome Numbers in the Genus *Saccharum* and its Hybrids. *Ind. Jour. Agric. Sci.*, Vol. IV, Pt. II, April 1934.

(4) Gopala Iyer, K. V. and Venkatraman, T. S. Suggested method of juice analyses for sugarcane plantations devoid of laboratory facilities. (Accepted for publication in the July 1934 issue of *Agric. & Live stock in India.*)

(5) Panje, Rama Rao . *Saccharum spontaneum* L. A comparative study of the forms grown at the Imperial Sugarcane Breeding Station, Coimbatore. *Ind. Jour. Agric. Sci.*, Vol III, Pt. VI, December 1933.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST

(J. N. Mukerji, B.A., B Sc.)

I. CHARGE

Mr. J. N. Mukerji, Assistant Agricultural Chemist, held charge of the section throughout the year, in addition to his own duties.

II. EDUCATION

Of the two post-graduate students, Messrs. Mohini Nath Phukan, M.Sc., and Sailesh Chandra Sen, M.Sc., who were admitted in November 1932, the former is still continuing his studies. The latter left the course on the 22nd December 1933 to join the appointment of assistant chemist at the Sugarcane Research Station, Musheri, under the Bihar Agricultural Department.

Messrs. K. Swaminathan, M.Sc., and Narendra Kumar Das, M.Sc., who were admitted to the post-graduate course on the 8th November 1933, are continuing their studies.

III. METEOROLOGY AND DRAIN-GAUGES

The usual meteorological records (except that of anemometer from 16th January to date) and records of drainage from four drain-gauges were maintained. Owing to the heavy damage done to the Institute building by the great earthquake of the 15th January, the readings of the anemometer, combined Anemo-Biagraph and Wind Direction Recorder, and the Natural Syphoning Recording Rain-gauges which were set up on the roof of the Institute building, had to be discontinued.

In connection with drain-gauges, sann-hemp and wheat crops from the gauges and 175 samples of drainage waters were examined.

IV. GENERAL ANALYTICAL WORK AND ASSISTANCE GIVEN TO OTHER SECTIONS

The following samples were analysed and reported upon :—

Soil	41
Manures	21
Feeding stuffs	17
Oil seeds	12
Sugarcane	467
Water	5
Drugs	7
Miscellaneous	2

Besides those made in connection with the work of this section, the analyses made for other sections of the Institute and for departments and persons outside Pusa are indicated briefly as follows:— For the Agricultural Section eight samples of manures, 308 of Sugarcane in connection with the farm's variety test, manurial experiments, trashing experiments, etc., seven of soil, and seven of feeding stuffs were analysed. For the Botanical Section, 12 samples of linseed, five of manures, six of barley flour, seven of Ganja (Indian Hemp) and one of tomato fruit, were analysed. The barley flour samples were examined for their starch, proteid, fat, ash and fibre contents in order to see how they compare with the barley flour imported from foreign countries. Of the seven Ganja samples examined, Flat Ganja Type 1 was found to be the best, both in respect of specific rotation and resin content. Besides these a report on the chemical composition of 34 samples of soil and subsoil and on the mechanical analysis of 90 samples of soil and subsoil from Karnal Sub-Station under the Imperial Economic Botanist, was issued. A report on the chemical analysis of 10 samples of soil and subsoil, and on the mechanical analysis of 24 samples of soil and subsoil from Karnal Sugarcane Area under the Sugarcane Expert, Coimbatore, was also made.

For the Mycological Section 91 samples of sugarcane from mosaic tonnage plots, and one of nutrient solution were examined. For the Bacteriological Section, one sample of kudzu vine, and three of silage prepared from kudzu vines were analysed, and for the Entomological Section 68 samples of sugarcane were analysed in connection with the damage done by top shoot borer, stem borer, root borer and termites, individually and collectively.

Four samples of soil and four of manures were received from the Assistant Director of Agriculture, Bannu, North-West Frontier Province. One of these samples of soil contained a high percentage of water soluble salts mostly in the form of sulphates. All the four samples of soil were very deficient in available phosphoric acid content. A sample of Bara river silt was received from the Agricultural Officer, N.-W. F. Province, Peshawar, for examination of its manurial value. This silt compared to Gandak river silt was far superior both in respect of nitrogen and phosphoric acid contents and had an appreciable manurial value. 22 samples of soil received from the Sugarcane Specialist, Sugarcane Research Station, Musheri, were examined for their hydrogen ion concentration. A sample supposed to be of calcium sulphate, received from the Director of Agriculture, North-West Frontier Province, was found to contain about 70 per cent. chalk and no calicum sulphate.

Analysis of five samples of soil and five of spring water from Kalat was carried out for the Irrigation Officer in Baluchistan, and two of manures carried out for the Military Grass Farm, Lucknow.

V. RESEARCH

1. Crops

Effect of manures on the yield and quality of sugarcane.—The manurial experiment with sugarcane (Co. 213) was carried out in 1933-34 with a view to ascertain if the quality and yield of the crop could be improved when sulphate of potash and superphosphate of lime are applied either separately or together, in addition to mustard cake. The experiment was a repetition of the one carried out in 1932-33, when owing to the vigorous growth of the crop attended with rainfall and high wind, a considerable part of canes had lodged and the germination in few of the plots were affected owing to the existence of big trees in the vicinity.

The conditions prevailing during the year under observation were fair and the experiment was conducted with bigger plots in 4 replications for each treatment in Latin squares. The following treatments for the purpose were adopted: (1) Mustard cake at 100 lbs. N. per acre, (2) Mustard cake at 100 lbs. N. with sulphate of potash at 50 lbs. K_2O per acre, (3) Mustard cake at 100 lbs. N. with superphosphate of lime at 100 lbs. P_2O_5 per acre and (4) Mustard cake at 100 lbs. N. *plus* superphosphate of lime at 100 lbs. P_2O_5, *plus* sulphate of potash at 50 lbs. K_2O per acre. The size of each plot was 46 ft. by 33 ft. A border crop 3 ft. all round was excluded at harvest and the inner crop covering an area of $\frac{1}{40}$th acre for each plot was taken into consideration for the purpose of the experiment. The manures were applied in two doses, $\frac{1}{3}$rd at the sowing time and $\frac{2}{3}$rds three months after sowing. The germination was uniform and the crop grew well and at the harvest gave an yield varying from 1,078 to 1,200 maunds per acre for different treatments.

The application of superphosphate of lime with mustard cake had the effect of increasing the yield over mustard cake alone by about 120 maunds per acre, and that of superphosphate with sulphate of potash and mustard cake by about 123 maunds per acre, over mustard cake alone. Sulphate of potash with mustard cake had the effect of increasing the yield over mustard cake alone by only 24·4 maunds per acre. The results were found to be statistically significant with the former two, while with the latter, it was not significant. With regard to the available sugar, superphosphate with mustard cake, and superphosphate *plus* sulphate of potash *plus* mustard cake gave an increase over mustard cake alone by 14·4 and 12·9 maunds per acre respectively. Sulphate of potash with mustard cake had the effect of increasing the quantity of available sugar by only 3·9 maunds per acre over mustard cake alone. As with the total yield, so with the available sugar also, the former two treatments gave significant results, while the latter did not.

Considering the result from the economic point of view superphosphate with mustard cake gave the best result, both in respect

of total yield and of available sugar. As regards the quality of juice it was hardly affected by any of the above manurial treatments.

Experiment on the quick availability of Natural Indigo for *dyeing purpose.*—Natural Indigo from Bihar is prepared into dry cakes for the market and contains about 60 to 65 per cent. indigotin. It cannot be used for dyeing purpose readily. The cake has to be ground into a very fine powder, converted into a paste of uniform consistency and reduced by bacterial action or by reducing agents to Indigo white (which is soluble in water), before it can be used for dyeing purpose. Finally the cloth dyed in the indigo white on exposure to atmosphere, is oxidised by the oxygen of the atmosphere and the indigo white changes to indigo blue. Indigo, whether natural or synthetic, is insoluble in water and it has to be reduced to indigo white, before it can be used for dyeing purpose. For the reduction of indigo to indigo white readily, one of the necessary conditions is to bring the indigo into the form of a paste of uniform consistency with the particles remaining in suspension in as fine a state as possible, or in other words it should be brought into a colloidal state.

With a view to bring the paste into a colloidal state and to maintain it in such state without fermentation when kept in sealed tins, the paste, as reported last year, was treated with sodium carbonate in proportion of 1, 1·5 and 4·5 per cent. on the weight of paste and subsequently heated in water bath for 8 hours at 80°C. 1 and 1·5 per cent. sodium carbonate proved totally ineffective, inasmuch as the paste fermented very badly within 4 days. Treatment with 4·5 per cent. sodium carbonate, however, stopped fermentation to a good extent, without in any way diminishing the indigotin content or destroying the strength of colour. Treatment with sodium carbonate in proportion of 1·5 per cent. of the weight of paste and subsequent heating at 120°C. under 1 atmosphere pressure for 40 minutes in autoclave, as reported last year, proved successful and completely stopped fermentation. The same result was obtained by treatment with 1·5 per cent. sodium carbonate, and subsequent heating *in air oven at a temperature of 105°C. for 12 to 15 hours.*

Trials with such antiseptics as borax and sodium salicylate in proportion of 1·5 to 2 per cent. of the fresh indigo paste as available immediately after *Mahai*, were given. Sodium carbonate as already shown, does not interfere with the chemical determination of indigotin, so sodium salicylate too ; but borax on the other hand interferes and gives a misleading result. The use of borax as an antiseptic, therefore, had to be abandoned. Treatment with sodium salicylate at 1 and 2 per cent. on the weight of paste and subsequent heating in air oven at 105°C. for 12 hours proved as effective as with sodium carbonate. A trial was given with 5 per cent. sodium salicylate, which was thoroughly mixed with the paste and kept in sealed tins *without heating.* This treatment successfully prevented

the fermentation and decomposition of the indigotin. As a preservative sodium salicylate was found better than sodium carbonate. The contents of the sealed tins treated with sodium salicylate, when opened and examined after four months were found to be unchanged and free from fermentation. It is now intended to give dyeing trials with the indigo pastes preserved with sodium carbonate and sodium salicylate and find out how they compare with ordinary natural indigo cake.

2. Soils and Fertilizers

The study of lime requirement of an acid soil.—Mr. S. Das continued the study on the lime requirement of soils during the year. *Ragi* (Eleusine coracana) was grown in the several groups of pots of Jorhat acid soil under varying doses of lime based on its lime requirement. When seedlings were about one month old, a photograph was taken of them, which showed a progressive growth according to various treatments. When however the crop was harvested, the grain did not show any marked difference in mean yields.

A crop of oats was next raised in these pots last winter with the renewal of a basal dressing of nitrogen, phosphate and potash. The plants in pots which had the heaviest application of lime rendering the acid soil distinctly alkaline with a pH of 7·6 flowered latest of all and behaved similarly to the plants in pots containing the original soil with no addition of lime and having a pH of 4·7.

The crop yields in pots where lime was added in proportion of 1/3, 2/3, and equivalent of lime necessary for complete satisfaction of the lime requirement of the Jorhat acid soil were distinctly better than those secured with the control where no lime was applied. In pots where 2, 3 and 4 times the lime necessary to satisfy the lime requirement were added and thus alkalinity was developed in the several soil mixtures, the crop yields were very poor, even lower than the control. The experiments are being continued with *ragi* as the *kharif* (monsoon) crop in these pots after a renewal of the basal dressing of nitrogen, potassium and phosphorus.

The Limiting factor of phosphate requirements of Calcareous soils.—Calcareous soils belonging to the trans-Gangetic alluvium and containing from 30 to 40 per cent. of chalk respond to the application of phosphatic fertilizers. It is not however exactly known what amount of phosphate gives the best cropping results. Of course, the amount required will depend, other things being equal, upon the kind of crops grown. In order, however, to arrive at a working figure for ordinary agricultural practice, two series of pot experiments with Pusa soil containing about 35 per cent. of chalk were carried out with *ragi* (Eleusine coracana) under various doses of calcium phosphate. Basal dressing of potash and nitrogen were given to all the pots at the rate of 80 and 100 lbs. per acre respectively. Potash was applied as potassium sulphate, and nitrogen as

ammonium sulphate and green manure separately in the two series. The crop yield showed that the application of 100 lbs. of P_2O_5 per acre or 0·005 per cent. P_2O_5 to Pusa soil proved better than lesser applications of phosphates. The results were found to be statistically significant when examined by the Fisher's method of analysis of variance. The application of higher doses of P_2O_5 even upto 1,600 lbs. per acre did not produce significantly better yields.

Another fact emerging from these experiments is that the application of green manure did not prove better than ammonium sulphate when applied to supply nitrogen, both of them rather yielded practically identical results.

The experiment was repeated last winter with mustard applying P_2O_5 as tri-calcium phosphate in pots at the rate of 60, 70, 80, 90 and 100 lbs. per acre with basal dressing of nitrogen as ammonium sulphate only and potash as potassium sulphate. Although different doses of phosphate produced better yield than the control, and the results were found to be statistically significant, there were not however significant differences between mean yields of different treatments owing perhaps to the crop being damaged by *aphis* and other insects at the maturing stage. The experiment is being continued with *ragi* as the *kharif* crop to arrive at the actual limit of phosphate requirement of these calcareous soils. A series of field experiments with modern technique has also been started in order to work out the phosphate requirement. Superphosphate has been applied to supply P_2O_5 at the rate of 50, 70, 80, 90 and 100 lbs. per acre. A basal dressing of potash and nitrogen has been given to all the plots at 80 and 100 lbs. per acre as sulphates of potassium and ammonium respectively. There is a group of control plots for comparison. *Ragi* seedlings have been transplanted for *kharif* crop to be followed by a *rabi* (winter) crop in order to study the residual effect of the manures.

Availability of superphosphate in Calcareous soils with placement of depth.—Several workers have shown that phosphorus remains largely where it is placed in the soil, and hence the failure to obtain a profitable response to superphosphate in calcareous soils may be due to the improper placement of the fertilizer. Should therefore superphosphate be applied at different depths in such soils, a variation in response is expected, depending on whether a crop is shallow-rooted or a deep-rooted one, and in this way the proper depth of application of superphosphate can be discovered for particular crops. With this object in view superphosphate was applied at 100 lbs. P_2O_5 per acre to several groups of pots containing a calcareous soil (Pusa) at different depths, *viz.*, at surface, and at 4, 8, 12 and 16 inches below the surface, and also mixed throughout the whole mass of soil. There was a group of control pots for comparison where no phosphate was applied. Basal dressings of potash as potassium sulphate and nitrogen as ammonium sulphate were given at 80 and 100 lbs. per acre respectively. Mustard was grown.

Cropping results showed that the application of superphosphate to soil at 4 inches below the surface gave the best yield, and then the yields gradually fell with the lowering of the depths of application of superphosphate. The yields from application of superphosphate at surface and of superphosphate mixed throughout the whole mass of soil in the pots were almost identical and the least, when compared with the yields obtained from other applications, all of which however produced higher yields than the control. It is therefore evident that the application of super at 4 inches below the surface gives the best results in calcareous soils with a crop like mustard. After the harvest 4 inches soil borings at different groups of pots were taken and the examination of their total phosphate contents showed that the phosphate did not reach downwards from the depths where it was applied. This is in accordance with the observation of other workers. A fresh series of pot experiments has been started under almost similar lines with *Eleusine coracana* as the *kharif* crop.

Relative availability of natural and artificial phosphate in calcareous soils.—With a view to study the relative availability of some natural and artificial phosphates in calcareous soils, a series of pot experiments were started in the winter of 1933. Natural phosphates like bonemeal, apatite and Trichi-nodules which are available in quantity in this country, and also artificial phosphate like superphosphate, di- and tri-calcium phosphates, and phosphates of ammonium, sodium, potassium, magnesium, iron, and aluminium were used to supply phosphates at the rate of 100 lbs. of P_2O_5 per acre to pots having a calcareous Pusa soil with about 35 per cent. of chalk. A basal dressing of potash and nitrogen at 80 and 100 lbs. per acre was given to all the pots as sulphates of potassium and ammonium respectively. There was a group of control pots for comparison which contained no phosphates. Mustard was grown as the *rabi* (winter) crop.

The results showed that the pots treated with phosphates always produced a higher crop return than the control, and the increased yield varied between 19 and 127 per cent. over the control according as the different phosphatic manures were used. Natural phosphate as well as aluminium phosphate gave rather lesser yield, compared to the rest of the phosphates. The results when examined by the Fisher's method of analysis of variance, were found to be statistically significant in all cases except with apatite and aluminium phosphate, which, however, produced higher crop yields than the control. Trichi-nodules gave statistically significant results for 5 per cent. and the rest for even 1 per cent. level of significance.

Eleusine coracana has been grown as the next *kharif* crop to study the residual effect of these phosphatic manures, if any. In this connection, a scheme of field experiments with modern technique has been drawn, to be carried out during the coming winter in order

to study the relative availability of some natural and artificial phosphatic manures in calcareous soils.

The manurial value of different phosphates in calcareous soils.—In connection with the investigation on this subject carried out by Mr. Das in this laboratory some time ago, further experiments on the reaction of calcium carbonate with different sodium phosphates used were conducted. It was found that there was no action between calcium and sodium meta and pyro-phosphate solutions even after prolonged shaking. Such a reaction is improbable, as higher phosphates of calcium are not formed at ordinary laboratory temperature, but require a pretty high heat for their preparation. Consequently the absence of any reaction ensures a more uniform distribution of these phosphates and their consequent better manurial value in calcareous soils. The conclusion is therefore forced that the higher soluble phosphates of the type containing either PO_3 or P_2O_7 ions which have no reaction with calcium carbonate give the best cultural results in calcareous soils by effectively supplying the phosphatic nutrition of plants, notwithstanding the presence of an inordinately large amount of chalk in them.

A reaction, however, takes place between calcium carbonate and disodium hydrogen phosphate solution. The relationship between the amount of P_2O_5 precipitated by calcium carbonate and the time of reaction is a simple semi-logarithmic one, and can be expressed by the general equation

$$\log t = ay - k$$

where y is the amount of P_2O_5 retained in time t and a and k are constants. Under the experimental conditions, the reaction is strongly retarded and can only reach completion at the end of a considerable period of time, which when calculated from the experimental data is found to be over six months. These experiments were carried out by shaking the reacting substances in a comparatively large volume of water, and do not approximate to soil conditions, where these substances are static and where the volume and the rate of movement of water are comparatively small. Therefore, *in situ* in soil the rate of such action will be far slower. Hence soluble phosphates of the above type reacting slowly or not at all with calcium carbonate as in the case of sodium meta- and pyro-phosphates, will have enough time during the growing season to get themselves easily distributed more uniformly into deeper layers, resulting in a wider and deeper root action and better cropping in calcareous soils.

The effect of Potash on yield in calcareous soils.—The apparent ineffectiveness or even depressing effect of potassic fertilizers, used alone on yield has been observed in several field experiments conducted at Pusa. In order to arrive at a definite conclusion on this point and with a view to find out if the ineffectiveness or depression indicated in the field trials at Pusa is due directly to potash or to

some other indirect cause, properly conducted experiments with wheat in pot and field were started during the last cold weather.

The pot experiment was designed to compare the independent effect, in calcareous soils of potash as (*a*) potassium sulphate and (*b*) potassium carbonate with that of nitrogen as ammonium sulphate, and P_2O_5 as mono-calcium phosphate, without the basal dressings in any of the sets. Besides the control, one of the sets in this experiment included calcium sulphate, the individual effect of which in highly calcareous soils was also studied along with others.

The results of pot experiment, in case of ammonium sulphate and mono-calcium phosphate, on being statistically treated by the Fisher's method of analysis of variance, were found to be significant. In case of other applications, the results were not significant. The highest mean yield was from mono-calcium phosphate which gave an increase of 130 per cent. over the control and the least was from potassium sulphate which decreased the mean yield by about 5 per cent.

The field experiment was laid over 25 small plots of equal area where the individual effect of potash as (*a*) potassium sulphate, (*b*) potassium carbonate and (*c*) potassium chloride was tested. As in pots, so here too the effect of calcium sulphate was also studied. None of these applications of potassium salts, when treated statistically, gave significant results.

Based on the results of the pot experiment, a series of field experiment with modern technique has been started in the Pusa Farm in order to compare the individual effect of potash with the individual effect of nitrogen and of phosphate. Superphosphate has been applied to supply P_2O_5 at the rate of 80 lbs. per acre and ammonium sulphate applied to supply nitrogen at the rate of 80 lbs. per acre. Potash as (1) sulphate of potash, and (2) potassium carbonate, each at 40 lbs. per acre, and Gypsum (Calcium sulphate) at 60 lbs. per acre have been applied. There is a group of control plots for comparison. *Ragi* (Eleusine coracana) seedlings have been transplanted for the *kharif* crop to be followed by a *rabi* crop next winter in order to study the residual effect of these manures.

The limiting factor of potash requirements of calcareous soils.—In order to find out the limiting factor of potash requirements in calcareous soils, two series of pot experiments with a calcareous Pusa soil have been started. In the first series sulphates of potash and ammonium have been altogether eliminated as well as calcium sulphate which is contained, to a large extent, in the commercal superphosphate. Commercial ammophos has been used in all the pots to supply both nitrogen and phosphate as a basic dressing at 80 and 100 lbs. per acre respectively instead of ammonium sulphate and superphosphate. Potassium chloride has been used in the place of potassium sulphate to supply potash to groups of pots in different doses varying from 20 to 100 lbs. per acre in order to arrive at an

actual limit of potash requirement of these calcareous soils. *Ragi* has been grown as the *kharif* crop, to be followed by barley or any other suitable crop in the *rabi* season in order to study the residual effect.

In the second series, as in the case of previous experiment, sulphates of potash and ammonium, and commercial superphosphate have been applied in the same doses as in the first series. Except the variation of manurial treatment, the procedure followed in both the series is identical.

The fresh weight of twelve *ragi* seedlings of a fortnight's growth from each group of four pots under various doses of potash manures were taken for comparison. In both the series the seedlings exhibited a significant response to the various doses of potash in addition to the basal dressing of nitrogen and phosphate. This effect was, however, more pronounced in series I than in series II. It may perhaps be due to the adverse action of sulphates of potassium and ammonium on calcium carbonate present in calcareous soils and to the deleterious effect of calcium sulphate already contained in the superphosphate used in series II. The subject is under study.

Efficiency of wild apricot seed cake as a nitrogenous manure.— Earlier work in this laboratory reported last year has shown that about 60 per cent. of nitrogen present in the cake may be transformed into available forms in three dissimilar types of soil, *viz.*, Pusa, Kalianpur and Solon soils in about two months' incubation. Pot experiments have since been conducted with these soils with the following conclusions :—

(1) The application of 80 lbs. of nitrogen per acre as cake produced the maximum yield of wheat in Pusa and Solon soils and 100 lbs. in Kalianpur soil. The results obtained were statistically significant, when examined by the Fisher's method of analysis of variance.

(2) According to the increasing doses of the cake varying from 20 to 100 lbs. of nitrogen per acre the crop yield increased from 85 to 155 per cent. over the control in Pusa soil, 94 to 300 per cent. in Kalianpur soil and 19 to 94 per cent. in Solon soil.

(3) The residual effect of the cake was tested in Pusa soil alone, where 100 lbs. of nitrogen only gave significantly higher yields of *ragi* (Eleusine coracana) over the control, the rest of the applications giving somewhat higher yields than the control, though not statistically significant.

(4) From the curves of crop yield with various doses of the cake a similarity of manurial effect is apparent in Pusa and Solon soils, whereas in the case of Kalianpur soil this effect though similar for two doses only, *viz.*, 40 and 80 lbs. of nitrogen per acre, is not so for the rest. This

effect is, however, most pronounced in Kalianpur soil demonstrated by a remarkably high crop yield.

(5) The cake being effective with an important crop like wheat in three different types of soil, it will undoubtedly prove as an efficient nitrogenous manure for soils which are particularly deficient in this constituent, and specially so on agricultural lands in the neighbourhood of Solon near Simla Hills where it is available in plenty, but at present wasted as a fuel only.

Study of soils of tobacco tracts in India.—During the year under report, tobacco soils from Saharanpur in the United Provinces, Guntur in Madras and Dacca in East Bengal, were obtained. At Saharanpur the tobacco crop is grown during monsoon between June and September, harvested towards the end of September and cured during October. Saharanpur and most of the north-western districts of the United Provinces are visited by frost during winter and if tobacco is grown in these parts during winter season, as is the case in other tobacco growing districts of India, the crop is very likely to be spoilt by frost. Saharanpur soil being mostly sandy, it is possible to grow tobacco here during monsoon without much trouble.

The chemical examination of 8 samples of tobacco soils that were obtained from the Kaira district in Northern Gujarat last year have been completed. Almost all the soils that were obtained from this district were found to be rich in their nitrogen, phosphate and potash contents, the available phosphate in most cases being unusually high.

Owing to the heavy damage done to the Institute building by the great earthquake of the 15th January, resulting in the dislocation of work, and the removal of the laboratory from the Institute building to a temporary building which had to be fitted up with gas and water, the progress of laboratory work was considerably hindered, and the examination of the soils that were brought from Rangpur and other places during last year could not be completed.

3. Animal Nutrition

Experiments on the feeding value of various fodders.—In the method of valuation of fodders by the starch equivalent system, only that part of the food which the animal assimilates, and which is considered as of direct value, is taken into account. Digestibility experiments have been carried out in Europe and America, but very little has been done in India. In the absence of any such figures as "digestibility coefficients" of Indian feeding stuffs and fodders tried with Indian cattle, Dr. Kellner's figures are the only guide, at present for working out the starch equivalent and arrive at the feeding value of different feeding stuffs and fodders.

The live weight of an average European cow or bullock is much higher than that of an average Indian cow or bullock and the power of assimilation of an average European cow or bullock cannot be similar to that of an average Indian cow or bullock ; consequently Dr. Kellner's figures are not applicable in case of Indian feeding stuffs and fodders tried with Indian cattle.

Digestion experiments with reference to certain fodders on six bullocks have therefore been started in collaboration with the Physiological Chemist and the Imperial Agriculturist. In this connection two experiments each lasting for ten days have been completed. In the first experiment, three animals were fed on oatstraw and three on maize silage in addition to rape cake which was common to all. In the second experiment oatstraw was substituted by oats hay and maize silage by Berseem silage mixed with oat straw. Preliminary feeding is going on for the third experiment with Berseem hay and maize kutty as the roughages.

VI. RESEARCH PROGRAMME FOR 1934-35

1. *Study of the Soils of tobacco tracts in India.*—Physical and chemical examination of typical tobacco soils already obtained from Rangpur (Bengal), Dacca (East Bengal), and Guntur (Madras) will be continued. Typical tobacco soils from the districts of Trichinopoly and Madura in Madras and from Cooch Bihar and Jalpaiguri in Bengal will be obtained for the purpose of this study.

2. *Effect of potash on the yield of crops.*—The yield of *kharif* and *rabi* crops from the 25 small experimental plots in replications of five for each treatment will be recorded for the year 1934-35. Pot culture experiment to compare the effect of potash with that of nitrogen and of phosphate will be repeated. A series of field experiments on the same line as that of pot culture, has been started in the Punjab Experimental Area of the Pusa Farm. *Eleusine coracana* seedlings have been transplanted for a *kharif* crop to be followed by a *rabi* crop. The results when ready will be submitted to the Fisher's method of analysis of variance in order to find out the significance.

3. *Effect of manures on sugarcane.*—The effect of oil cake (mustard cake) alone, and in combination with either superphosphate of lime or sulphate of potash or both, will be further studied on sugarcane grown in randomised plots in replications of six for each treatment. Besides these, effect of (1) molasses with sulphate of ammonia and (2) molasses with sulphate of ammonia and superphosphate of lime will be studied in randomised plots in replications of six for each treatment. There will be control plots as well.

4. *Lime requirement of acid soils.*—The cropping power of an acid soil by means of pot experiments after the addition of incremental amounts of lime in proportion to its lime requirement is to be further examined. *Eleusine coracana* has been grown as the *kharif* crop in an acid Jorhat soil for the purpose. There is also a corresponding series of uncropped pots side by side to supply sample of soil for periodical examination in the laboratory.

5. *Limiting factor of phosphate requirements of calcareous soils.*—(*a*) Pot experiments are being continued on the addition of calcium phosphate at the rate of 50, 70, 80, 90 and 100 lbs. of P_2O_5 per acre to arrive at an actual limit of phosphate requirement of calcareous soils. *Eleusine coracana* has been grown as the *kharif* crop for the purpose.

(*b*) A similar series of field experiments with modern technique has been started in the Punjab Experimental Area of the Pusa Farm. *Eleusine coracana* seedlings have been transplanted for a *kharif* crop to be followed by a *rabi* crop in order to study the residual effect of the manures, if any.

6. *Availability of superphosphate in calcareous soils with depth of placement.*—The failure to obtain a profitable response to superphosphate in calcareous soils may be due to the improper placement of the fertilizer. In order to test this, pot experiments with a calcareous Pusa soil are being continued, in which superphosphate has been placed at surface and at 3″, 6″, 9″ and 12″ below the surface, and also mixed throughout the mass of the soil, each to a group of four pots. There is a group of control pots for comparison. *Eleusine coracana* has been grown as the *kharif* crop.

7. *Relative availability of natural and artificial phosphates in calcareous soils.*—(*a*) Pot experiments with a calcareous Pusa soil where different phosphatic fertilizers were applied and a crop of mustard raised last winter, are being continued this summer in order to study the residual effect of these manures with *Eleusine coracana*.

(*b*) There is also a scheme of field experiments with modern technique to be conducted in the Punjab Experimental Area of the Pusa Farm next winter in order to study the relative availability of some natural and artificial phosphatic fertilizers in calcareous soils.

8. *The limiting factor of potash requirements of calcareous soils.*—Pot experiments have been started with a calcareous Pusa soil to which potash has been supplied in different doses varying from 20 to 100 lbs. per acre in the form of chloride and sulphate of potassium separately in series I and II. In one series nitrogen and phosphate have been supplied as ammophos, and in the other as sulphate of ammonia and superphosphate as a basic dressing to all the pots. There are control pots for comparison. *Eleusine coracana* has been grown as the *kharif* crop, which will be followed by a *rabi* crop in order to study the residual effect of potash manures, if any.

9. *The effect of manures on the vertical distribution of P, $CaCO_3$, and replaceable bases of calcareous soils.*—3″ soil borings up to 5′ depth have been taken from the nine Permanent Experimental Plots of the chemical section and a fallow plot of the Pot culture House Area. These samples are to be examined for P, $CaCO_3$, N, C, K_2O, clay and certain physical properties and replaceable bases in order to find out the effect of manures on the distribution of P, $CaCO_3$ and replaceable bases in calcareous soils and their relation to other relevant factors.

10. *Solubilization of apatite by chemical methods.*—Treatment with different chemicals will be attempted to render apatite available to plants.

11. *Colorimetric determination of phosphorus in soils.*—Troug and Meyer's modification of the original colorimetric method will be tested to compare a few important methods of determining readily available phosphorus of type soils in India with known manurial and cultural history and to arrive at a suitable standard of their phosphate requirements.

12. *Critical Examination of Pemberton Kilgore method of estimating phosphoric acid.*—It is intended to make a critical study of the method.

13. *Experiments on the feeding value of various fodders.*—Digestion experiment on the following fodders, *viz.*

1. Berseem hay (2nd cutting)+Green maize *kuttee*
2. Berseem hay (3rd cutting)+*meth* and *juar*
3. Berseem hay (4th cutting)+*sanwi* grass

will be carried out.

VII. PUBLICATION

Das, S. . . . . The Manurial value of different Phosphates in calcareous soils (submitted for publication).

REPORT OF THE PHYSIOLOGICAL CHEMIST.

[F. J. Warth, D.Sc. (Bir.), B.Sc. (Lond.), I. A. S.]

I. CHARGE

I was in charge of the section for the year with the exception of the period from 1st July 1933 to 22nd November 1933, when Mr. A. Viswanatha Iyer, Assistant Physiological Chemist, was in charge.

II. LABORATORY WORK

The following is a list of analyses completed during the year :—

Complete analyses—		
1. Fodders	40	
2. Faeces	75	
		115
Dry matter in faeces, urine, fodders, etc.		2,106
Single nitrogen determination in fresh faeces, fodders, urine, etc.		292
Mineral analyses of urine, fodders, faeces, etc.		232
Determination of protein, phosphoric acid and calcium in blood of cattle		200
Miscellaneous		401
Total		3,346

III. RESEARCH WORK OF THE SECTION

1. Experiments on Milk Production

(*a*) *High and low protein feeding.*—Further information is available from the experiment commenced last year. The accompanying table shows the daily average food consumption and the milk yield per head for each group. Figures are given for the first four weeks and for the first twenty weeks of lactation respectively.

Food consumption and Milk yield by Cows on High and low protein ration

	Average for first four weeks lactation		Average for first twenty weeks lactation	
	A Low protein	B High protein	A Low protein	B High protein
	lbs.	lbs.	lbs.	lbs.
Fodder dry matter . . .	11·97	10·47	11·61	10·44
Concentrate matter . . .	9·66	11·21	8·08	9·18
Total matter	21·63	21·68	19·69	19·62
Do. digestible protein . .	2·36	3·58	2·01	2·36
Do. starch equivalent . .	11·27	12·35	10·16	10·98
Milk Yield lbs.	18·40	21·40	14·70	17·20

The points to be noted are :—

1. Total food consumption for the two groups is identical. To compensate for the extra concentrate given to group B the cows of group A eat more fodder.

2. Although the total food is identical the food of B group contains a higher proportion of concentrate and hence possesses a higher starch equivalent value. Corresponding to the higher starch equivalent value of the ration there is a higher milk yield. This matter of milk yield requires corroboration by repeated tests, which are about to be commenced.

3. The protein content of ration B is very high. The tests must be continued to see how the cows tolerate the high protein level.

In a general way the data confirm the starch equivalent values assigned by the Nutrition Section to our foodstuffs.

(*b*) *Experiment to determine the value of Molasses for milk production*.—The two groups of cows selected for this experiment, though well matched in other respects, differed initially in milk yield, and hence it is difficult to judge the effect of subsequent feeding.

The accompanying tabular statement shows that the rate of decline in milk yield of the two groups was identical, which indicates that the two rations were equivalent in value and effect.

Table showing the average daily food consumption dry matter milk yield and live weight.

No. of week	Non-molasses group			Molasses group		
	Total dry matter consumption in lbs. per day	Average daily milk yield in lbs.	Average daily live-weight	Total dry matter consumption in lbs. per day	Average daily milk yield in lbs.	Average daily live weight
1	22·203	17·6	745	20·460	16·4	739
2	22·430	17·2	748	20·710	15·9	740
3	21·720	16·9	749	20·570	15·8	741
4	21·950	16·6	752	20·560	15·6	742
5	22·190	16·4	755	10·170	15·9	740
6	21·097	15·5	759	20·030	15·0	744
7	18·930	15·3	754	17·780	15·0	747
8	20·213	15·1	755	One animal sick in molasses group.		
9	20·360	14·9	758	19·230	14·1	744

The consistent and curious difference in food consumption between the two groups is noteworthy and requires consideration. Part of the difference is accounted for by the fact that molasses were used weight for weight to replace some of the concentrate. As the molasses contain much water, the molasses group received somewhat less concentrate dry matter (7·8 lbs. as compared with 8·4) In addition to this shortage in the provision, the molasses group consumed less fodder by choice (12·1 lbs. as compared with 12·8).

Generally a short provision of one item of the ration leads to increased consumption of the other items. In the above molasses test there has been no such balancing effect.

2. Experiments with Working Bullocks

Preliminary experiments with working bullocks have been carried out during the present season.

Three pairs of large cross bred bullocks were employed on ploughing work. The work was measured by determinations of the draft, the speed of movement and the total distance traversed daily. The food consumption was determined accurately and the live weight noted daily.

The test was divided into two periods the first period being on light work with a small plough and the second period on heavy work with a heavy plough.

Unfortunately owing to a change of weather, the work decreased very considerably in successive weeks. The following table shows

the average live weight and average daily work performed by one bullock :—

Week ending	Average live weight lbs.	Average work Million foot lbs.
12th May 1934	1139	1·72
17th May 1934	1136	1·87 light work.
26th May 1934	1142	1·80
2nd June 1934	1130	7·33
9th June 1934	1122	7·14
16th June 1934	1117	6·76
23rd June 1934	1116	6·51 heavy work.
30th June 1934	1117	6·94
7th July 1934	1115	5·96
14th July 1934	1120	6·38

It is generally understood that the draft should not exceed one-tenth of the live weight. In these tests the draft has been one-fifth to one-sixth of the live weight and yet the animals have not shown any sign of suffering.

The live weight figures show that there was a smart and appreciable fall when the heavy work commenced, but the fall became less and eventually equilibrium of live weight was established. The food consumption data would seem to indicate that the animals were not consuming enough food for the work done. Viewed from these various points the results are remarkable.

There is one feature which remains to be noticed, namely the gait of the animals. These bullocks move very slowly (average about 98 ft. per minute when ploughing). The work is performed slowly and the horse power developed is relatively low.

These tests seem to indicate that the gain of efficiency due to slowness of performance is greater than anticipated.

For comparison a few tests have been carried out with one pair of Mysore bullocks. It was observed that these animals have a naturally fast gait (163 ft. per minute when ploughing) with the consequence that the work they did was performed rapidly. It is noteworthy that with these animals the loss of condition became serious although their food provided more nearly the theoretically necessary starch equivalent than was the case with the large slow moving animals. Here it appears that rapidity of performance has materially reduced the efficiency of utilization of food energy.

The data are interesting from various points of view and will be submitted for publication at an early date.

3. Digestibility trials with coarse fodders

This work has been continued along the lines followed during the past two years, the main object being to determine the effect of advancing maturity upon composition and digestibility.

Some typical results obtained during the past season are shown in the accompanying table which gives the percentage of protein and carbohydrate found in early and late cuts of grass together with digestion coefficients obtained by digestion experiments with these samples :—

—	Crude protein			Carbohydrates		Amount digested
	Per cent Amount.	Digestion Coefficients	Amount digested	Per cent. Amount	Digestion coefficients	
Aurangabad hay 1st cut.	4·16	34·5	1·43	80·2	52·1	41·8
2nd cut	2·58	11·5	0·30	80·6	51·1	41·2
3rd cut	1·66	..	..	81·5	47·9	39·0
Spear grass, 1st cut .	5·60	41·9	2·35	82·2	55·9	47·1
(Bangalore) 2nd cut .	3·18	13·8	0·44	85·6	49·2	42·1
Rhodes grass, 1st cut .	11·38	59·4	6·76	76·9	64·7	49·7
(Bangalore) 2nd cut .	6·26	41·2	2·58	83·4	58·0	48·4

The figures agree well with previous results confirming the conclusion arrived at regarding the relationship between digestibility and protein content of fodders. (Memoirs of the Department of Agriculture for August 1930, Volume XI, No. 4.)

In the tabular statement it will be noticed that the digestion coefficients for protein and carbohydrates increase as the protein content of the fodder increases.

The high protein content and the high digestibility of rhodes grass (protein and carbohydrates) compared with spear grass grown on similar land is noteworthy.

4. Experiments with Legume Hays

The work under this head consists of digestion and nitrogen balance experiments. The common legumes in use as or available as fodder in India are being examined. Tests have been carried out this year with ground nut hay, cowpea hay and lucerne.

A test to compare fresh lucerne and lucerne hay deserves notice. It is well known that losses in hay making are due partly to fermentation, partly to mechanical loss of brittle material. The combined losses are liable to be very serious.

This year for our experiments fresh lucerne was sundried on sheets in order to minimise mechanical loss.

The total loss in this operation is accurately known from weighments of the initial and final products and the moisture determinations (12 of each). The figures are as follows :—

——	Weight. lbs.	% dry matter	Total dry matter. lbs.
Fresh lucerne	1,859	15·09	280·5
Lucerne hay (therefrom)	310	78·55	243·5

Here loss of dry matter due to conversion into hay is 37 lbs. or 13%. Having regard to the procedure employed, the mechanical losses probably only account for a small part of this total, which shows that fermentation may be considerable even under ideal conditions of conservation. There is no doubt that fodder conservation is an important subject requiring study in India.

The chemical composition and digestibility of fresh lucerne and the identical material converted into hay as above are shown in the accompanying table :—

——		Crude protein	Ether extract	Fibre	Nitrogen free extract	Total carbohydrates
Chemical composition.	Fresh lucerne . .	22·0	2·3	27·8	35·2	63·0
	Corresponding hay .	21·3	1·4	29·4	35·2	64·6
Digestible coefficients.	Fresh lucerne . .	80·0	45·8	49·7	72·3	62·3
	Corresponding hay .	77·0	29·7	50·0	67·9	59·7

There is practically no change in the chemical composition and only a very slight diminution in the digestibility. The results are unusually good.

5. Minerals in Pasture Grasses

This work to which Mr. Iyer has devoted attention for several years is beginning to yield important information.

The following tabular statement shows the mineral composition of three pure species of grass grown at Bangalore during two consecutive seasons.

Percentage mineral composition of grasses grown at Bangalore

	Stage of maturity	1932.			1933		
		Before flowering	In full bloom	Dead ripe	Before flowering	In full bloom	Dead ripe
Andropogon contortus.	Ash	12·57	10·93	8·59	11·71	7·46	9·99
	Ash soluble in Hcl	8·18	7·25	3·67	4·39	2·73	2·22
	P_2O_5	0·628	0·428	0·188	0·317	0·158	0·159
	CaO	0·603	0·558	0·403	0·528	0·301	0·384
	MgO	0·407	0·417	0·295	0·300	0 224	0·206
	Na_2O	0·168	0·273	0·225	0·222	0·211	0·208
	K_2O	3·861	3·206	1·511	1·867	1·109	0·568
	Crude protein	15·100	10·925	4·863	5·050	2·882	3·474
Cynodon dactylon	Ash	11·60	12·01	8·89	15·48	11·8	9·72
	Ash soluble in Hcl	7·02	5·08	4·58	8·66	7·08	5·11
	P_2O_5	0·508	0·474	0·302	0·641	0·549	0·245
	CaO	0·874	0·762	0·436	0·735	0·637	0·384
	MgO	0·377	0·269	0·426	0·390	0·355	0·254
	Na_2O	0·548	0·529	1·486	0·375	0·333	0·173
	K_2O	3·058	1·826	1·553	3·284	2·830	2·453
	Crude protein	14·681	11·893	8·275	14·825	10·235	8·601
Pennisetum cenchroides	Ash	13·49	11·72	9·22	14·15	11·41	11·29
	Ash soluble in Hcl	9·20	7·77	5·19	9·27	5·44	4·67
	P_2O_5	0·671	0·501	0·306	0·634	0·444	0·469
	CaO	0·432	0·436	0·480	0·382	0·526	0·372
	MgO	0·368	0·432	0·451	0·333	0·340	0·337
	Na_2O	1·350	1·583	1·173	1·311	0·811	0·603
	K_2O	3·887	3·050	1·620	4·378	1·916	1·717
	Crude protein	14·369	11·913	7·056	10·450	8·019	7·438

The first point to which notice is drawn is that while *Cynodon dactylon* and *Pennisetum cenchroides* are much alike during the two seasons, *Andropogon contortus* gave a very much richer product in 1932 than in 1933. This difference cannot be due to climate because the other two grasses show no such variation. The fact is that the *Andropogon contortus* was a new plantation in 1932 sown in very deeply and thoroughly cultivated land. The abnormally rich growth and mineral abundance of *Andropogon contortus* in 1932 must be accounted for simply and solely as the effect of cultivation.

It is an interesting and most important fact that cultivation may produce such a striking effect.

The second point to note is that the existence of certain specific differences in mineral assimilation are indicated and corroborated by data of two successive years.

For example, *Cynodon dactylon* has a tendency to contain more lime than the other species and the lime definitely exceeds the phosphoric acid.

Pennisetum cenchroides contains less lime than cynodon dactylon and at times seems to contain more phosphoric acid than lime which is unusual.

6. Digestion of fats

In connection with this subject experiments have been carried out to test methods for determination of fat in foods and faeces.

In a series of tests, using petroleum ether as solvent, the amount of substance extracted in successive six-hour periods was determined. The following are typical results :—

Rate of extraction of fats, etc., from fodder and faeces with petroleum ether expressed in mgms. per 100 grams dry substance.

Period of extraction	*Ragi* straw	Faeces	Groundnut cake
I 6-hour period . . .	459·4	951·6	9,894·0
II ,, ...	46·6	41·6	52·0
III ,, ...	23·3	31·2	10·4
IV ,, ...	6·7	15·6	..
V ,, ...	13·4	20·8	..
VI ,, ...	13·4	10·4	..
VII ,, ...	43·4	20·8	10·4
VIII ,, ...	13·4	20·8	10·4
Next 60 hours	182·0	156·0	208·0
Showing the incompleteness of extraction.			
Official method for 16 hours . .	529·3	1,024·4	9,956·4
Subsequent 92 hours . . .	272·3	244·0	228·8

It is quite possible that the fractions which are resistant towards the solvent are also resistant to the digestive juices. To clear up the matter extraction is now being undertaken on a larger scale.

To overcome the extraction difficulties, many authorities recommend alkaline hydrolysis. The Alkaline Hydrolysis method has been tested by the Nutrition Section, but for our materials it has not been found suitable.

Further tests are being made.

7. Experiments with Sheep

The main purpose of the experiments with sheep is to study the requirement and utilization of sulphur compounds.

This is a continuation of the experiments in which the Physiological Chemist showed that inorganic sulphate is assimilated by cattle.

The following typical data from the tests with sheep show that the animals are making use of inorganic sulphate to an appreciable extent. The utilization of sulphate is enhanced when a sulphate supplement is fed :—

Utilization of sulphate by sheep

Grams sulphur per day absorbed (+) lost (—)

Experiment No.	With sulphate supplement.	No supplement.
1	+0·069	—0·026
2	+0·155	+0·004
3	+0·179	+0·023
4	+0·192	+0·004
5	+0·204	+0·085
6	+0·215	+0·017
7	+0·298	+0·134

The following figures show that the ingestion of inorganic sulphate causes increase of organic sulphur :—

Increase of organic sulphur excreted in urine when a supplement of sodium sulphate is fed

Organic sulphur excreted in urine (grams per day)

Experiment No.	With supplement	No supplement
1	0·040	0·028
2	0·061	0·013
3	0·061	0·027

Maintenance requirements for sheep

The animals used for the sulphur metabolism experiments are virtually on a maintenance basis. They receive a small amount of groundnut cake and a little green fodder. The remainder of their requirements they take as they need from standard hay provided *ad lib.* The daily hay consumption is determined. With this rationing procedure the live weights of the animals have remained practically constant during six months. The amount of food consumed should be, therefore, a good estimate for the maintenance requirement of our Indian Sheep.

The figures are given in the accompanying table :—

Average food consumption in lbs. per day by sheep weighing 60·4 lbs.

Food	Consumption lbs. dry matter	Digested	
		Crude protein	S. E.
Green grass	0·251	0·009	0·073
Cake	0·110	0·053	0·096
Hay	1·247	0·000	0·337
Total .	1·608	0·062	0·506
Total per 1,000 L. W. .	26·6	1·28	8·38
Kellner standard (for coarse breeds)	18—23	1·0	8·3

Our starch equivalent corresponds closely with Kellner's standard but our food consumption has been somewhat higher.

8. Physiological Studies

(*a*) *Acid-base balance*

During the past year the work on this important subject has been devoted to the study of the influence of the maturity of the crop upon the acid-base balance.

The experimental fodders were fed to bullocks and the resulting urine examined.

In every case it was found that the early cut fodder produces the greatest volume of urine and the highest alkalinity. With later cuts the volume and the alkalinity both decrease.

The accompanying figures show the gradual change which takes place in the nature of the urine and in the acid-base balance as more mature fodder is fed :—

Per 100° gms. fodder

Total urinary excretion of acids and alkalis in c. c. N.

	Jowar Hay		
	1st cut	2nd cut	3rd cut
Alkalis	655·4	411·4	330·1
Chlorine	251·0	162·2	136·7
Sulphate	7·7	10·2	12·0
Organic acids	155·3	155·9	141·3
Total acids	414·5	328·3	290·0
Excess alkali	240·9	83·1	40·1
Carbondiaoxide	274·6	115·8	41·9
Ammonia	5·4	5·5	3·3
p^H (urine)	7·90	7·60	7·40
p^H (faeces)	7·60	7·35	7·25
Volume of urine excreted in litres per day	5·964	4·131	3·543

With some overripe fodders decidedly acid urines were obtained and in one case there was a marked nutritional acidosis, the normal ammonia output being increased about ten fold. This was entirely due to the food.

(*b*) *Blood Analysis*

Work on the following lines has been in progress during the past year :—

(*a*) A study of the influence of different fodders on blood Ca and P :—

(*b*) Seasonal variation of blood Ca and P in cattle maintained under natural grazing conditions, with special reference to the relationship between blood minerals and breeding.

The influence of foodstuffs on blood Ca and P is shown in the following table of data obtained by the Nutrition Section during the past season :—

Ca and P Variations in Blood due to different fodders

Roughage	Maturity	Animal	mgm. Ca per 100 c.c. serum	mgm. P per 100 c.c. serum
Aurangabad hay	1st cut.	D	10·66	5·2
		E	10·98	4·95
	2nd cut.	D	11·04	5·23
		E	12·47	4·98
	3rd. cut.	D	12·97	4·35
		E	13·42	5·53
Jowar hay	1st cut.	H	10·59	6·27
		V	11·70	5·88
	2nd cut.	H	10·78	5·53
		V	10·91	5·24
	3rd cut.	H	12·37	6·51
		V	12·86	5·64
Spear grass hay	1st cut.	C	11·31	5·24
		F	11·44	6·73
	2nd cut.	C	12·52	4·70
		F	13·81	6·26

It may be noted that with each foodstuff, the blood Ca tends to increase as the fodder becomes more mature.

It is a remarkable fact too that very similar values are obtained at each stage from all three fodders. There does not appear to be a corresponding regularity in the blood P but Aurangabad hay seems to give slightly lower values than the other fodders tested. Similar tests with various fodders showed that a certain sample of rhodes grass hay was quite unique in the abnormally high values for blood Ca which it produced (16—18 mgm. Ca per 100 c.c. serum). This point is being further investigated at present.

Some figures relating to seasonal variation of blood Ca and P are shown in the following table :—

Ajjampur Blood Samples—Ca and P (Mgm. per 100 c.c. serum)

Serial No.	Animal	March		April	
		Ca.	P.	Ca.	P.
1	Badagini . . .	13·27	5·70	11·67	6·30
2	Belevasavi . . .	13·14	4·24	12·95	7·74
3	Belegeji . . .	14·59	4·25	13·33	6·60
4	Chunchanagiri . .	13·93	3·99	13·01	8·59
5	Devagiri 8,25,16 . .	14·20	2·66	12·70	6·84
6	Devagiri 3,21,11 . .	12·41	4·54	12·05	6·95
7	Halithai . . .	13·07	5·84	12·12	7·32
8	Kalmari . . .	13·47	3·18	12·63	5·83
9	Masani	12·87	4·02	12·50	7·38
10	Muthaide . . .	12·94	6·40	12·25	8·53
11	Ramgiri . . .	11·68	·43	12·05	9·26
12	Sinani	15·05	4·10	13·53	7·06
	Average . . .	13·39	4·78	12·57	7·37

The noteworthy point in these figures is that a consistent rise in blood P has taken place at a time (April) when the P content of the natural herbage is falling to its lowest level. The main objective in this newly initiated work is to study the relationship between blood minerals and breeding a question of very great practical importance.

(*c*) *Sulphur Partition in Grasses*

Work on this subject has been in progress for some time. It is too early to discuss the data so far obtained.

IV. CO-OPERATION WITH OTHER DEPARTMENTS

(*a*) *Military Farms Department.*—As usual many valuable fodder samples have been provided by the Military Farms Department. Digestion and other tests have been carried out with this material.

(*b*) In the work on pasture grasses the section is receiving help from Pusa and also from Bombay, Bengal and Bihar and Orissa Departments of Agriculture.

(*c*) Very interesting work on blood composition is being carried out through the facilities offered by the Mysore Department of Agriculture. The same Department has also taken great pains to provide the Nutrition Section with fodder samples.

V. PUBLICATIONS

The following papers have been submitted for publication :—

1. Mineral Assimilation from two typical fodders.
2. A Note on Powell and Whittaker's method for the determination of Pentosans.

REPORT OF THE IMPERIAL MYCOLOGIST

(M. Mitra, M.Sc., Ph.D., D.I.C.)

(1) MYCOLOGICAL SECTION, PUSA

I. CHARGE

Dr. Mitra was in charge of the Section from 28th April, 1934.

II. DISEASES OF PLANTS

(i) Sugarcane

The investigation of mosaic and other diseases of sugarcane which was formerly the major subject of the Section was completely transferred to the Mosaic Sub-Section financed by the Imperial Council of Agricultural Research, but substantial help was rendered by the staff of the main Section in the survey of mosaic disease, roguing, etc. A detailed account of this work is given in part 2 dealing with work done on mosaic and other sugarcane diseases under the Scheme mentioned above.

Tonnage experiment.—A paper entitled " Effect of Mosaic on the Yield and Juice of Sugarcane in Pusa, III " giving the result of last year's (1932-33) investigations was published in the Indian Journal of Agricultural Science, Vol. III, Pt. V, 1933, pp. 870—880, and the experiments were continued under the guidance of Dr. W. McRae. The experiments were carried out on the same line as mentioned in the previous year's report and a paper entitled " Effect of Mosaic on the Yield and Juice of Sugarcane IV," giving the result of the year under review by Dr. W. McRae and L. S. Subramaniam has been submitted for publication.

(ii) Wheat

Bunt disease.—The study of the bunt disease of wheat caused by *Tilletia indica* Mitra was continued by Dr. M. Mitra. The morphology and germination of spores was studied in detail and the biometrical analysis of spore measurement data of bunt from Karnal and Peshawar showed that there are at least two physiological

forms of *T. indica* the average diameter of spores of these two forms being $37 \cdot 9 \times 32 \cdot 5\mu$ and $36 \cdot 2 \times 34 \cdot 7\mu$ respectively. It has also been shown by a series of infection experiments done at Karnal and Pusa that infection does not take place at Pusa whereas at Karnal infection does take place. This is due to difference in climatic conditions. In order to determine the effect of some fungicides on the incidence of *T. indica* an experiment was carried out at the Botanical Sub-Station, Karnal, during the year. The fungicides tested were copper carbonate, ceresan, formalin and uspulun (universal). Untreated wheat seed was also sown as control, thus making up five treatments in the experiment. The three varieties of wheat used were Karnal-grown seed of Pusa 111, 112 and 113. There were two methods of infection, *viz.*—series A—naturally infected seed and series B—naturally infected seed *plus* an extra dose of artificial infection by shaking every 100 grams of seed with one gram of bunt powder. The experiment was carried out on a piece of land which was laid out in a randomized block system with eight replications. Each block contained thirty plots, each plot being $10' \times 5'$ in size, fifteen under infection series A, and fifteen under infection series B. There were five treatments and three varieties in each series. At the time of harvest the percentage of bunted ears in each plot was determined. The data obtained were statistically analysed according to Fisher's analysis of variance. It was noticed that infection in series B was significantly higher than in series A, that is, the extra dose of infection given in series B had definitely increased the percentage of bunt. It was further noticed that the percentage of infection can be reduced by treatment with the fungicides mentioned above but none is able to check the disease altogether. Uspulun (universal) gave the best results. The bunt spores are well protected especially in mildly attacked grain by the pericarp covering and the fungicides cannot reach the spores. Hot water treatment may perhaps be a possible method to check the disease to a greater extent and as loose smut is also very common, this one treatment would control both the diseases. There is an indication that, as in other bunts, infection can take place from infected soil and so a suitable rotation of crop is advisable. A paper entitled 'Stinking smut (bunt) of wheat with special reference to *T. indica*' was submitted for publication. Experiments will be carried out during the year to test the hot water treatment in controlling the bunt and smut.

Helminthosporium sativum P. K. & B. and *H. tritici-repentis* Died.—The percentage of leaf area destroyed by these two species of Helminthosporium was again estimated on varieties of wheat grown at Pusa and Karnal. At Karnal, the attack was much less during the year and with the exception of traces on a few varieties, it was absent altogether on other varieties of wheat. At Pusa the weather was very favourable for the disease, and the two fungi, especially *H. sativum*, were present in a severe form. There was a good deal of

variation in the percentage of attack, not only from plot to plot but also in the same plot. For instance in 1932-33 the range of percentage of leaf area destroyed in the case of Pusa 4 was from 12·7 to 23·3 with an average of 17·2 while in the Botanical Area it was from 5·3 to 9·3 with an average of 7·6. During the year under report the same variety in the Farm had a range from 23·7 to 27·1 with an average of 24·8 while in the Botanical Area the range was 17·1 to 34·4 with an average of 23·9. Other varieties behaved in a similar fashion. From the above example it will also be seen that the percentage of leaf surface destroyed by these fungi was far more during the year.

A paper entitled "A leaf spot disease of wheat caused by *H. tritici-repentis* Died." was sent for publication.

Loose smut of wheat.—The "loose smut of wheat" caused by *Ustilago tritici* (Pers.) Jens. was rather bad at Karnal especially on Punjab 8A grown round about the Botanical Sub-Station. Last year also the smut was very common on Punjab 8A and it is quite evident that all Pusa types grown at Karnal which were free from the disease got infection from spores blown from this wheat. The percentage of infected ears was determined and the following is an average of six counts :—

P. 4 —2·2%		P. 12 —1·7%
P. 80-5 —3·6%	P. 111 —0·49%	P. 112 —1·4%
P. 113 —0·49%	P. 120 —3·7%	P. 165 —1·4%
P. 114 —0·0%	Punjab 8A —24·2%	

Pusa 114 was found to be free from smut and it appears to be highly resistant to the attack of smut. As all the types may have been further infected from spores blown about from Punjab 8A, 258 maunds of various wheat varieties were treated for the Imperial Economic Botanist, Pusa, against smut by the solar heat method, that is, the seeds were soaked in water for four hours and then exposed to the solar heat for four to five hours during June when the atmospheric temperature used to go up as high as 120°F.

Wheat rust.—A survey of wheat rust on all the varieties of wheat grown in the Botanical Area and the Farm at Pusa and on all the varieties grown in the Botanical Sub-Station, Karnal, was again made during the year. The date of first appearance of three rusts during the last three years at Pusa was as follows :—

	1931-32	1932-33	1933-34
Orange	26-12-31	29-12-32	20-12-33
Yellow	16-1-32	3-2-33	19-1-34
Black	5-2-32	13-2-33	7-2-34

During the year all the three rusts appeared rather earlier and the attack by orange rust was more severe as compared with the previous year. The variety most affected was Pusa 12. The yellow and black rusts were mild in their attack. An estimate of the leaf surface covered by the rust pustules was made and the average percentage of leaf area by the orange and yellow rusts in all the varieties of wheat grown in Pusa is given below :—

Wheat varieties	Botanical Area		Farm Area	
	Orange	Yellow	Orange	Yellow
P. 4	Traces	..	Traces	..
P. 12	8·1	Traces	4·5	..
P. 52	1·28	·25	Traces	Traces
P. 111	·54	..	·20	,,
P. 101	4·2	..	Traces	,,
Federation	..	..	,,	,,
Country	1·9	Traces	9·3	
K. 12	5·4	,,	..	..
K. 12-2	15·7	..	..	..

From the above table it will be noticed that the severity of attack varies in the same place, that is, P. 12 had 8·1 per cent leaf area affected by orange rust in the Botanical Area but had only 4·5 per cent in the Farm Area. P. 52 had 1·28 in the Botanical Area but only traces in the Farm. Similar variation is also noticed in other wheat varieties.

Orange and black rusts were slightly more prominent at Karnal during the year and yellow rust was as bad as last year especially on P. 52.

Aeroscopic slides for rust spores were again placed in wheat fields both at Pusa and Karnal for Dr. K. C. Mehta of Agra and exposed slides were sent to him at regular intervals from 15th September, 1933, to 15th March, 1934. Similar slides were also exposed for the Section at various places. Further help was given to Dr. Mehta by sending fresh specimens of rusts for his infection experiments. Infection experiments with rust material supplied by him were carried out on wheat seedlings to note the incubation period. A detailed report was supplied to Dr. Mehta.

(iii) Rice

Sclerotial diseases.—Experiments in plots highly infested with the sclerotia of *Sclerotium oryzae* Catt. (=*Leptosphaeria salvinii* Catt.) again gave negative results as the typical sclerotium disease was not seen. It did not appear in the pot experiments also but the plants in the latter were all sterile and the straw, on harvesting, showed the presence of sclerotia. It seems rather doubtful whether the fungus is parasitic under Pusa conditions. Unless the parasitism of the fungus can be demonstrated, there is not any purpose in studying the organism culturally and much progress with it has therefore not been made. Further pot and field tests have been undertaken by Dr. B. B. Mundkur.

Sclerotium oryzae did not develop the perfect stage reported from U. S. A., nor the *Helminthosporium sigmoideum* Cav. conidial stage. However tentative studies with the various isolations of rice Sclerotia have shown that aside from *S. oryzae*, there are three other Sclerotium species which do not so far seem to have been named. One sclerotium-forming fungus of the Rhizoctonia type seems definitely to be a new species, a view with which S. F. Ashby of the Imperial Institute of Mycology, Kew, agrees.

(iv) Oats

Smut diseases.—Smut appeared in a severe form in 1932-33 at Pusa and an investigation was undertaken with a view to control the disease. Examination of the smutted panicles showed that they were affected by covered smut, *Ustilago kolleri* Wille. Though this is the most common smut in India, strangely enough it has not been so far recorded even though an illustration of it is given in Butler's 'Fungi and Disease in Plants'. Examination of the Pusa Herbarium specimens showed that of the fifteen smut collections, only two were of Loose smut, *U. avenae* (Pers.) Jens. while all the rest were of Covered smut, but all bore the name, *U. avenae*. Samples of smutted panicles were subsequently obtained from Sind, the Punjab, United Provinces of Agra and Oudh, and Bihar and Orissa, and their examination made it manifest that covered smut is the predominant smut of oats in India.

The disease was brought under complete control by treating the seed with formaldehyde using the dry spray method. On a hundred acre area sown with treated seed, only two smutted heads were seen while on a twenty-five acre area sown with untreated seed, smut ranged from 1·5 to 16·9 per cent. In a well replicated test, treated seed yielded statistically higher quantity of grain than untreated seed. Two papers were written up by Dr. Mundkur and sent for publication and a leaflet on the dry spray method was written for the Bihar and Orissa Department of Agriculture.

(v) Barley

Helminthosporium sativum P. K. & B. was present in a virulent form during the year on several varieties of barley grown in the Botanical Area and the Farm and was responsible for the shrivelling and discoloration of the kernels. The spot formation due to this fungus was also noticed on the awns which became brownish and brittle and produced plenty of conidia. . In several cases the seeds produced were totally destroyed by the fungus. An estimate of the percentage of leaf area destroyed by *H. teres* Sacc. and *H. sativum* P. K. and B. was again determined during the year on twenty-four types of Pusa barley and on other foreign and Indian varieties grown at Pusa. The combined percentage of leaf area destroyed by both species of Helminthosporium on twenty-four types of barley ranged from 4·6 to 23·9 as compared to 0·22 to 20·45 during last year. The infection due to *H. teres* and *H. sativum* ranged respectively from 1·1 to 20·7 and 1·1 to 16·8 as compared to 0·27 to 20·5 and 0·22 to 6·78 during last year and 0·5 to 25·4 and 1·2 to 14·2 during the previous year. Other Indian and foreign varieties had only *H. sativum* and the attack was severer than that of the previous year.

The experiment to test the comparative resisting power of twenty-four types of Pusa barley to the attack of species of *Helminthosporium* was repeated and in addition to uspulun (universal), ceresan was also used in the treatment of seeds. Altogether there were six treatments and each treatment had six replications, comprising 144 plots. All the seedlings which died of 'foot-rot' or 'root-rot' were removed twice a week and examined, when the crop was fully grown the percentage of leaf area destroyed and the yields were estimated. The efficacy of uspulun was again confirmed, and it was further noticed that ceresan is equally good in controlling the disease. Though both fungicides are good in controlling foot and root-rots, they cannot help in controlling the attack on leaf surface as a good deal of secondary infection takes place by means of air borne spores. All the data obtained are being statistically examined.

Smut.—The smut disease of barley caused by *Ustilago hordei* (Pers.) Kell. and Sw. is very common in Pusa and the surrounding areas and does a good deal of damage. During the year the seeds both in the Botanical Area and the Farm were treated with ceresan before sowing, and there was no sign of smut in the plots where treated seed was sown while in a plot where untreated seed was sown the smut was very bad. The efficacy of formalin, uspulun and ceresan to control the smut was tested on a small scale. Plots treated with ceresan and uspulun had no smutted ears while those treated with formalin had 0·5 per cent. of smutted plants as compared with the control (untreated) which had six per cent smutted plants.

Rust.—The yellow rust caused by *Puccinia glumarum* (Schm.) Erikss. and Henn. was present in a very slight form at Pusa on Types 1, 7, 9, 10, 12, 21 and 24 and all the other types were free. At Karnal, Pusa types 4, 13, 16, 18 and 21 and local 4 and 5 were grown. The yellow rust was bad on type 21 and all the rest were lightly attacked.

(vi) Hibiscus sabdariffa L.

Sclerotinia stem-rot.—This disease again appeared this year in the first week of January confirming the previous year's observations that it is primarily a cold weather disease. Trials to see whether the plants would mature and set seed earlier if sown earlier gave disappointing results, for seed sown in April, May, and June flowered almost at the same time and plants were ready for harvest at the same time also, *viz.*, end of February. It was noted that *sclerotia* when buried in the soil at a depth of three, six and nine inches, did not form apothecia but those buried at a depth of one inch and those that were placed on the surface of the soil developed them. Ploughing in the soil rather deep after harvesting the Hibiscus crop is therefore one of the methods of controlling this disease, for experiments have shown that the disease is brought about only by the ascospores that are formed about December when the cold weather sets in. *Sclerotia* of an authentic culture of *Sclerotinia sclerotiorum* (Lib.) de Bary, *S. minor* Jagger and *S. intermedia* Ramsay formed apothecia. The Hibiscus Sclerotinia agreed with *S. sclerotiorum* and spore measurements further confirmed this conclusion. The investigation was brought to a conclusion and a paper by Dr. Mundkur was sent for publication.

(vii) Crotalaria juncea L.

Wilt disease.—The study of the wilt disease of *Crotalaria juncea* caused by *Fusarium vasinfectum* Atk. was continued by Dr. Mitra. The fungus can be noticed on pods and in many cases on the seeds in diseased pods. Wilted plants have been found to produce large number of immature seeds and these seeds have the infection and are capable of disseminating the fungus at the time of threshing, thus infecting mature, viable and healthy seeds. As a certain percentage of wilt of sann-hemp is caused by the fungus carried by seed, it is advisable to disinfect the seed before sowing with some fungicides such as, uspulun (universal, 0·25 per cent.) for thirty minutes or mercuric chloride (1-1000) for ten minutes.

Infection experiments with sann-hemp and pigeon-pea *Fusarium* were repeated and the previous years' results were confirmed. The experiments carried out showed that sann-hemp and pigeon-pea wilt are caused by similar strains of *F. vasinfectum* under Pusa conditions and that sann-hemp strain of Fusarium can infect pigeon-pea but not cotton or sesamum, and the pigeon-pea strain can infect sann-hemp but not cotton and sesamum.

There appears to be a close association between soil temperatures and maturity on the one hand and incidence of Fusarium wilt in sann-hemp and pigeon-pea on the other, that is, the same fungus causes wilt in these two crops under two different sets of conditions. In sann-hemp high temperature favours the wilt while low temperature seems to favour wilt in pigeon-pea.

Infection experiments with *Rhizoctonia solani* Kuhn and *Neocosmospora vasinfecta* Smith isolated from wilted sann-hemp plants were repeated in sterilized soil and pathogenicity under local conditions was proved. In nature these two fungi produce wilt but to a minor extent. *Rhizoctonia solani* is generally found in young wilted plants. A paper entitled "Wilt disease of *Crotalaria juncea*" has been sent for publication.

Cercospora sp.—A species of Cercospora forming spots on the leaf, stem and pod of sann-hemp was found to be very common in Pusa. A single spore culture was obtained and infection experiments carried out proved its pathogenicity. It failed to produce the disease when cross inoculated on *Phaseolus aconitifolius*, *P. radiatus*, *P. mungo*, *Vigna catjang*, *Cajanus indicus*, *Stizolobium* sp. *Cyamopsis psoraliodes* and *Glycine hispida* and thus appears to be restricted to sann-hemp only. From the study of morphological and cultural characters by Mr. Udai Bhan Singh, it appears to be an undescribed species. A *Cercospora* sp. has also been recorded from Trinidad but does not seem to have been studied in detail.

(viii) Piper betle.

Foot-rot diseases of Piper betle in Bengal. In Bengal the 'foot-rot' diseases of betel vine are caused by three fungi, *Rhizoctonia solani* Kuhn, *Sclerotium rolfsii* Sacc. and *Phytophthora parasitica* Dast. The major loss to vine growers during the monsoon is due to the *Phytophthora* but just after the rains and in the early part of winter, the foot-rot is mostly due to *R. solani*. Only stray cases of *S. rolfsii* have so far been noticed in this delta. Flooding seems to promote the disease to a considerable extent, for in areas above the flood level and in years of scanty rainfall the disease does not cause so much loss. Warm summer temperatures are favourable for the growth of Phytophthora when it does the maximum damage while slightly cooler temperatures favour the growth of *R. solani*. Growing the vines above the flood level, clean culture and timely application of two fungicides, Bordeaux mixture and Kerol, control the disease. A large number of infection experiments were carried out on castor oil seedlings with various strains of Phytophthora isolated from betel vines. All took infection and produced spots on leaves. The measurements of sporangia under standard conditions were statistically analysed and the investigation was concluded and a paper entitled 'Foot-rot disease of *Piper betle* in Bengal' was sent for publication by Dr. W. McRae.

(ix) Phaseolus sp. and other pulses

Cercospora sp.—A comparative study of the species and strains of Cercospora isolated from *Phaseolus aconitifolius*, *P. radiatus*, *P. Mungo*, *Vigna catjang*, *Stizolobium* sp. and *Cyamopsis psoraliodes* was continued by Mr. Udai Bhan Singh with a view to determine whether there are a number of species or merely strains of a single species. The H-ion concentrations, the temperature relationships, the effect of light and darkness, the amount of medium and the zonation were studied. The spore size and septation on a number of media and at different temperatures were also measured. The study of the saltants obtained during the course of the study was concluded. A paper entitled " A comparative study of the species and strains of *Cercospora* parasitic on pulses " is being written up.

A species of *Cercospora* parasitic on the leaf, stem and pod of *Glycine hispida* (soy-bean) was isolated and a detailed study was made. The morphological and cultural characters do not agree with *C. daizu* Miura known to cause ' Frog eye leaf spot ' of soy-bean. All the varieties of soy-bean grown at Pusa were found to be susceptible to its attack. In severe cases the infection of the seed also takes place and the disease appears to be seed borne.

Colletotrichum sp.—A comparative study of the species and strains of Colletotrichum from various pulses and other hosts with a view to determining of the number of species and strains was started and single spore cultures were obtained from *Phaseolus aconitifolius*, *Dolichos lablab*, *Cajanus indicus*, *Glycine hispida*, *Vigna catjang*, *Phaseolus radiatus*, *P. Mungo*, *Stizolobium* sp. *Piper betle* and *Panicum frumentacium* and several of the isolates formed the perfect stage (*Glomerella*) in culture.

(x) Cicer arietinum L.

A survey of gram blight caused by *Mystrosporium* sp. was made on eighty-four varieties of gram grown in the Botanical Area. The blight was very bad on Type 68 and in a fair amount on Types 48, 49 and 67. On eighteen types the attack was slight and on thirty-four types it was present only in traces and the rest were free from the disease.

Methods of control were again studied. Seeds treated with formalin, uspulun (universal), sulphur and ceresan were sown using Types 68 and 69 but unfortunately the earthquake of 15th January, 1934, destroyed practically the entire experiment by the deposition of sand through fissure.

(xi) Tobacco

Stem-rot.—The investigation on the stem-rot disease of tobacco caused by *Sclerotinia sclerotiorum* (Lib.) de Bary was continued by

Mr. K. F. Kheswalla. Inoculation experiments carried out showed that infection can be brought about by whole or cut sclerotia as well as by ascospores. The fungus was studied in detail in culture and a paper entitled ' A stem-rot disease of tobacco' has been sent for publication.

Root-rot.—A disease of tobacco in which the leaves become yellow and later on turn brown was noticed at Rangpur (Bengal). The infected plants showed the symptoms of wilting and an examination of the underground parts showed that the root system was poorly developed, brittle, and in advanced cases rotting. Microscopic examination revealed the presence of a *Fusarium* which was isolated. The pathogenicity of this fungus is under investigation.

(xii) Amomum subulatum Roxb

Phurki disease.—This desease which came to the notice of the department in 1909 has been doing much damage to the greater cardamom in the Darjeeling District and the cultivation of the crop has almost become impossible. It is primarily a disease of the roots and when these are affected, the plants put on a very unthrifty appearance ; the leaves curl up and the plants soon become sterile and fail to bear seed. In some of the affected roots a species of *Cephalosporium* has been noticed by Dr. Mundkur but it remains to be seen whether it is pathogenic or whether the disease is not a sort of degeneration disease of the virus type, something like the " Katte " disease of Kanara cardamom (*Elettaria cardamomum* M. and W.).

(xiii) Fruit tree Diseases

A survey of diseases of fruit trees in British Baluchistan was again undertaken during the year and the following fungi in addition to those mentioned in the previous year's report were recorded by Mr. Kheswalla for the first time :—

Almond	*Alternaria* sp. (leaf-spot), *Coniothecium* sp (leaf-spot), *Oidiopsis* sp. (mildew) and *Cytospora* sp. (Die-back).
Apple	*Oidium* sp. (mildew) and *Cytospora* sp. (bark canker of seedlings).
Peach	*Alternaria* sp. (leaf-spot), *Coniothecium* sp. (leaf-spot), *Rhizopus* sp. (Fruit-rot) and suspected cases of yellow.
Pear	Die-back (Physiological).
Walnut	*Cytospora* sp. (Die-back).

The species of *Cytospora* do a good deal of damage to apple, almond and walnut. They are responsible for the formation of

canker in apple tree and die-back in almond and walnut. The symptoms of the three species on their respective hosts were studied and isolations made for comparative study.

Soft-rot of Peach.—A species of *Rhizopus* was isolated from peach fruits attacked with soft-rot disease. Infection experiments carried out on healthy unwounded peach fruits showed that it is capable of producing rot of peach.

Soft-rot of Apple.—A species of *Alternaria* was isolated from diseased apple and infection experiments carried out showed that in addition to causing soft-rot in wounded apples during transit, the fungus is capable of infecting healthy fruits as well.

Leaf-spot of Grape vine.—A leaf-spot disease of grape vine is very common in Pusa and a fungus which resembles *Guignardia* sp. was isolated. The fungus forms irregular, light brown to dark brown spots. Infection experiments carried out proved its pathogenicity. A single pycnospore culture has been obtained and the fungus is being studied in detail.

Black-rot of Chestnut.—Black-rot of chestnut fruits causes a good deal of damage to chestnuts in Kulu (Punjab). The surface of the diseased fruits become bluish black and the affected portion become brittle. In severe cases the discoloration extends deep into the tissue. The infection appears to take place at the stalk end of the fruit. A species of *Sclerotinia* and a species of *Cytospora* have been isolated. The former organism develops Botrytis stage in culture. A single conidium culture gave rise to sclerotial formation.

III. MISCELLANEOUS

Sclerotium rolfsii Sacc.—Studies on the growth of this fungus have been continued by Dr. Mundkur. Appearance of the *Corticium* stage once in culture was mentioned in the last year's report. In an agar medium containing an infusion of onions, proteose peptone and asparagin, this stage appeared in abundance in four strains and single sporidial cultures were obtained which grew into typical sclerotia, thus demonstrating genetic connection between the Corticium stage and the Sclerotial stage. It was also found that unless the temperature is around 31°C., the hymenium does not form the basidiospores. Further studies are in progress.

Several *Sclerotium* species isolated from Betel vines (Piper betle) and tentatively referred to *Sclerotium rolfsii*, have been examined further. One isolate is definitely *Sclerotium delphinium* Welch, a culture of which was obtained from the Imperial Institute of Mycology, Kew. There is another *Sclerotium* which differs in several respects from *S. rolfsii* and *S. delphinium* and it may possibly be a new one. A paper regarding the perfect stage has been sent for publication.

Cercospora tageticola Ell. et E. infecting leaf stem and inflorescence of *Tagetes patula* was observed for the first time. The disease was in an epidemic form. It is carried from diseased flowers to healthy flowers by means of honey bees which are the only insects visiting the flowers of *Tagetes patula*. Spores of this fungus were found sticking on the legs, wings and mouth of the honey bees.

A study of the fungus flora of pigeon-pea sick soil where pigeon-pea has been grown for the last ten years and the soil is heavily infected with *Fusarium vasinfectum* Atk. was undertaken by Mr. Udai Bhan Singh. *Fusarium vasinfectum* was found to be present in the soil at a depth of two feet. Several other fungi were found to be common especially species of *Aspergillus*, *Neocosmospora vasinfecta* Smith, and *Mucor*. Three Ascomycetes, *viz.*, *Delitschia* sp., *Magnusia* sp. and *Orbicula* sp. were also found in plenty. The number of colonies of fungi decreased with the depth.

Moisture contents of a typical sugarcane plot were determined regularly at an interval of one week till 15th January, 1934, when it became impossible to continue on account of the earthquake. The temperature of soil at a depth of six inches and twelve inches was recorded for the year and other meteorological observations taken in order to apply them to the incidence of a particular disease during a particular period.

IV. SYSTEMATIC WORK

The following fungi were recorded for the first time :—

Sorghum margaretiferum DC.	*Phyllachora sorghi* v. Hoehn. (Pattambi, Madras).
Oats	*Epicoccum neglectum* Desm. (Sabour).
Tobacco	*Phytophthora parasitica* var. *nicotianae* Tucker from the stem and roots (Anakapalli, Madras).
Panicum frumentaceum	*Colletotrichum* sp. on leaf and leaf sheaths. (Pusa).
Sugarcane	*Ceratostomella paradoxa* (de Seynes) Dade (Coimbatore), *Sclerotium rolfsii* Sacc. (Talipuramba, Madras), *Cercospora kopkei* Kruz. Ber. Zuck (Burma).
Hibiscus sabdariffa L.	*Colletotrichum* sp. and *Fusarium* sp. from stem affected with canker (Pusa).
Anona squamosa	*Pleosphaeropsis* sp. (Pusa).
Stizolobium sp.	*Cercospora* sp. (Pusa).

The identification of species of *Daldinia concentrica* on various hosts was revised and corrected. Fifty-one specimens of various fungi belonging to Ascomycetes were supplied to Dr. H. Sydow,

Berlin. Four specimens and two cultures to the Principal, Agricultural Institute, Allahabad, two specimens and two cultures to the Professor of Botany, Allahabad University, one culture to the Government Mycologist, Nagpur, two specimens and one culture to the Professor of Botany, Bethune College, Calcutta, three specimens to the Rice Specialist, Bihar and Orissa, and one specimen and two cultures to the Professor of Botany, Carmichael Medical College, Calcutta, were supplied. Thirty-one specimens from the Professor of Botany, Allahabad University, 200 from Dr. H. Sydow, Berlin, and eight from the Mycologist, Indian Tea Association, Assam, were received for our herbarium.

A large number of cultures were received from various workers in Agricultural Departments and Indian Universities for identification and where required remedial measures were suggested.

During the last few years 2,625 fungi from different sources or collected by the staff have been added to the herbarium, and attempts are being made to complete the revised "List of Mycological Specimens in the Herbarium." A large number of half named specimens were taken in hand to have them fully identified.

A good deal of assistance was given to the Bengal and the Bihar and Orissa Departments of Agriculture in the investigation of diseases of several crops.

The Section was also useful to a number of investigators in Mycology and Plant Pathology in other directions, *e.g.*, by supplying descriptions of fungi and literature pertaining to the subject on which they are working. A list of fungi causing diseases of potatoes and other tuber crops grown in India was prepared and sent to the Imperial Chemical Industries (India), Ltd.

V. PROGRAMME, 1934-35

1. Research, work

Owing to the earthquake of January 15, 1934, the work of the Section has been considerably dislocated and normal working cannot be resumed until the Section is properly housed. New diseases of Indian crops that come to the notice of the Section will however continue to be investigated. Diseases of the following crops will receive special attention :—Wheat, oats, barley, rice, tobacco, linseed, pulses and potatoes. The diseases of sugarcane will be investigated under Scheme of Imperial Council of Agricultural Research.

The investigation in progress include :—

1. Investigations on smuts of oats and barley.
2. A study of the bunt disease of wheat caused by *Tilletia indica* and remedial measures.

3. Studies on sclerotial and other diseases of rice.
4. A study of the diseases of cultivated grasses caused by species of *Helminthosporium* and determination of percentage of rust and *Helminthosporium* on various varieties of wheat and barley.
5. A comparative study of various strains of *Sclerotium rolfsii* and Rhizoctonia on various hosts including potatoes.
6. A comparative study of *Colletotrichum* on pulses and other crops.
7. Investigation on diseases of tobacco.

2. Training

Students and assistants will receive training on the lines indicated in the prospectus.

3. Routine work

Advice and assistance as required will be given to other departments and the general public.

VI. PUBLICATIONS

Kheswalla, K. F. . . . . Stem-rot of tobacco caused by *Sclerotinia sclerotiorum* (Lib.) de Bary. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. IV, Aug. 1934.]

McRae, W. . . . . Effect of Mosaic Disease on the Tonnage and the Juice of Sugarcane in Pusa, Pt. IV. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. V, Oct. 1934, pages 787—796.]

Do. . . . . Foot-rot diseases of Piper betle Linn. in Bengal. [*Ind. J. Agri., Sci.* Vol. IV, Pt. IV, Aug. 1934, pages 585—617.]

Mitra, M. . . . . Wilt disease of *Crotalaria Juncea* Linn. (Sann-hemp.) [*Ind. J. Agri., Sci.* Vol. IV, Pt. IV, Aug. 1934, pages 701—714.]

Do. . . . . A leaf-spot disease of wheat caused by *Helminthosporium tritici-repentis* Died. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. IV, Aug. 1934, pages 692—700.]

Do. . . . . Stinking smut (bunt) of wheat with special reference to *Tilletia indica* Mitra. [*Ind. J. Agri. Sci.*, Vol. V, Pt. I, Feb. 1935.]

Do. & Mehta, P. R . . . Diseases of *Eleusine coracana* Gaertn. and *E Aegyptiaca* Desf. caused by species *Helminthosporium*. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. VI, Dec. 1934, pages 943—975.]

Mitra, M. & Mehta, P. R. . .	The effect of Hydrogen-ion concentration on the growth of *Helminthosporium nodulosum* B. et B. and *H. leucostylum* Drech. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. V, Oct. 1934, pages 914—920.]
Mundkur, B. B.	A Sclerotinia-rot of *Hibiscus sabdariffa* Linn. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. IV, Aug. 1934, pages 758—778.]
Do.	Perfect stage of *Sclerotium rolfsii* Sacc. in culture. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. IV, Aug. 1934, pages 779—781.]
Do.	Influence of temperature and maturity on the incidence of Sann-hemp and Pigeon-pea wilt at Pusa. (Submitted for publication).
Do.	Oats smuts in India. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. IV, Part V, Oct. 1934, pages 895—898.]
Do. & Azmatullah Khan .	A Dry Spray method of treating oat seed against covered smut. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. IV, Part V, Aug. 1934, pages 899—905.] Popular abstract also published as pamphlet by Bihar and Orissa Dept. of Agriculture.

(2) SCHEME FOR RESEARCH ON MOSAIC AND OTHER DISEASES OF SUGARCANE

(Financed by the Imperial Council of Agricultural Research)
1933-34

(S. V. Desai, B.Sc., Ph.D.)

I. INTRODUCTION

The earthquake of 15th January 1934 disorganized the work but it has been possible to improvise laboratory accommodation in which work could be continued.

II. MOSAIC DISEASE

A. *Distribution.*—The occurrence of mosaic was noted on the following varieties in addition to those previously recorded :—

Shahjahanpur—Co. 331, 343, 347, 350, 360, 400, 401, 402, E. K. 28.

Padegaon—P. O. J. 2878, H. M. 607 and 609, and Elephant grass.

Jullundar—Co. 331, 356 M 2 and "Mogal".

B. *Natural spread.*—A row of each of the following thirty-six varieties was planted at Pusa alternately with a row of mosaic-infected Co. 213 :—

Co. 213, 214, 281, 285, 290, 299, 303, 312, 313, 316, 327, 331 341, 342, 343, 344, 345, 346, 347, 348, 349, 351, 356, 387, 388, 393, 395, 396, 397, Tuc. 393, 472, P. O. J. 2878, Saretha, Uba and Lalgirah, with a view to test the natural spread of mosaic in them. The disease did not appear in any of the varieties till the end of June 1934. The spread of the disease from March 1933 to February 1934 was noticed on Co. 301 (1 clump), Co. 313 (3 clumps) and Saretha (1 clump).

It has been noticed in previous years that the mosaic canes of Co. 213 did not give cent per cent mosaic plants. The result of germination of selected mosaic canes of Co. 213 in previous years is given below :—

1931-32 63·41, 1932-33 66·86 and 1933-34 78·50.

An experiment has been laid out to find what percentage of mosaic plants develop when mosaic setts of various varieties are planted. Further, whether the healthy plants developing out of mosaic setts continue to reproduce healthy canes is also being studied.

The spread of mosaic in Co. 213 from mosaic canes of the tonnage experimental plots to the adjoining healthy plots has been very small at Patna Farm. Only three clumps in two of the healthy plots were found to have mosaic by secondary infection at Patna and two clumps of similar mosaic infection were found at Cawnpore Farm. The Plant Pathologist, Cawnpore, reported that the spread of mosaic from diseased Ponda cane to healthy Ponda cane grown on that farm was so much that most of the healthy cane plots were infected and the experiment on the effect of mosaic on tonnage of Ponda was ultimately abandoned. Thus it appeared that the rate of natural spread in different varieties varied at one and the same place.

At Padegaon, where in previous year P. O. J. 2878 was free from mosaic, this year some of the plots of P. O. J. 2878 had considerable mosaic, the infection being as high as 12 per cent. in one of the plots. The setts with which these plots were planted were obtained from the same farm and were mosaic-free. The ratoon left after the removal of the crop for planting also showed no disease, thus making it doubly certain that the disease was not seed borne. The only disease on the farm during the previous year was two clumps of mosaic in H. M. 213 in the museum, and it is highly improbable that this had been the source of the present infection. During the year some elephant grass was imported from the Gokak Farm and the grass was found to be completely affected by mosaic. This being the only outside source of mosaic on the farm it is presumed that the disease spread from this to P. O. J. 2878 variety which was planted near by. The spread was found to be considerable and rapid which showed that the insect vectors had a favourable climatic condition for spreading the disease. Here it was noticed that the mosaic did not spread to Ponda canes grown near the diseased grass. They have been immune so far. No case of mosaic has yet been found in Ponda in the Deccan.

C. *Roguing.*—The whole area of 28·5 acres under sugarcane in the Pusa Farm was rogued and the varieties affected with the disease with the area under cultivation were as follows :—

Area	Variety	Clumps infected	Per cent. infected
13·84 acres .	Co. 213	2	·001
2·467 . .	Co. 281	4	·012
5·19 . .	Co. 299	4	·006
0·62 . .	Co. 344	2	·025

There were seventeen varieties under field conditions and fifty-six varieties in the nursery, and the disease was negligible. It thus appeared that by careful roguing, the mosaic was held in check as well as eliminated from most of the Coimbatore varieties.

D. *Artificial Transmission.*—It has been noticed that it is possible to transmit mosaic from one variety to another and furthe to jowar (*Andropogon sorghum*), *Euchlaena mexicana* and maize by infecting them with the juice of sugarcane mosaic leaves, but the reverse transmission of mosaic from jowar, *Euchlaena* and maize has not been possible.

The virulence of the mosaic virus has been noticed to vary with the climatic conditions and at Pusa the virus is of sufficient virulence for artificial transmission from 15th March to 15th June only.

The action of various chemicals on the virulence of the mosaic juice was studied. For this purpose the mosaic leaf juice was filtered through cheese cloth and the appropriate quantities of the chemicals were allowed to act for twenty minutes ; the juice was then inoculated into a batch of young plants and the transmission of the disease noted. HNO_3 (1 c. c. in 800), HCl (1 c. c. in 1,000), NaCl (1 in 25), $HgCl_2$ (1 in 1,000), $CuSO_4 \cdot 5\ H_2O$. (1 in 1,500), H_2O_2 12 vol. (1 in 25), formalin (1 in 50), inactivated the mosaic virus. These chemicals in lower concentrations did not inactivate the virus. Zinc powder and MnO_2 (1 in 20) did not retard the activity.

Effect of dilution.—Fresh sugarcane mosaic leaves were ground up with equal amount of water and the juice extracted through a cheese cloth. This juice was used as the standard. Ordinarily 50 gms. of leaves with an addition of 50 gms. of water gave 45 gms. of the standard juice. This was immediately diluted to appropriate strength and inoculated into a batch of plants in 10 pots. The result showed that dilutions beyond 1 : 10 were too dilute for infection. Thus the concentration and virulence of the virus was found to be very weak. With dilutions of 1 : 10 and less, the disease appeared in the inoculated plants.

The effect of ageing was also studied. The standard mosaic juice was kept at 20°C. for various lengths of time and inoculated into a batch of potted plants after different intervals. The time was measured from the moment of extraction of the juice. One hour after extraction the juice had the infective power but beyond that time it seemed to be inactivated. Thus the time the mosaic juice remains infective after extraction is very limited.

Experiments were carried out to test the filtrability of the mosaic juice. The standard mosaic juice was repeatedly poured in the same filter funnel till the filtrate was clear brown liquid. The paste left on the filter paper was well washed and suspended in distilled water and filtered on another filter paper. The washed paste and the clear filtrate were inoculated into the test plants. The filter paper filtrate was found to be non-infective while the washed green paste was found to be infective. It thus appeared that the infective principle remained more or less adsorbed on the

fine tissue particles and that the infectivity was lost even by filtration through a filter paper. Chamberland candle filtrates were not infective. But the serological tests in which the Chamberland candle filtrates were used to immunize the rabbits suggested that the virus did pass through the candle inasmuch as the immune serum inactivated the mosaic leaf juice.

E. *Nature of mosaic virus.*—Further work on the organisms associated with mosaic was carried out, cumulative evidence pointing to the filterable forms of these organisms as being closely allied to the virus. Isolations of the same type of organisms were made when sterilized pieces of infected sugarcane were placed on nutrient agar. The growth was observed to occur after a fortnight to a month. Healthy tissues similarly placed failed to show any growth. Occasional contaminations did take place but these were clearly seen as the growth in such tubes invariably occurred during the first few days after sealing the tubes containing the tissues. Further, ageing the diseased leaf juice after filtration through Chamberland filter candles for a month or so, then implanting it on agar medium and transferring the invisible film on the agar surface by washing it with a drop for two of nutrient broth induced the growth of this type of organisms after a few such transfers.

The effect of the age of the diseased plants on the number of transfers necessary to obtain visible growth was studied and it showed that with the advent of the monsoon the isolation became more protracted till the weather again became dry and hot. It was interesting to find that the virulence of the virus as measured by the relative chlorophyll contents followed a similar course and the disappearance of mottling on the leaves suggested the attenuation of the virulence of the virus during the monsoon. Difficulties of maintaining the cultures of these organisms were considerable as the transfers unaccountably failed to give visible growth and could not be revived even after a long series of passages in broth. The organisms were peculiar inasmuch as they gave all negative biochemical reactions and were unstable in their visible forms. The relative lengths of various cyclostages of these organisms were compared with those of Shiga Bacillus (in which filterable forms and other cyclostages are well studied). This established that these organisms were most stable in the " virus " cyclostage :—

	Bacterial cyclostage " R. & S" stage	Filterable cyclostage " g" form	Virus stage invisible growth stage
Shiga Bacillus . . .	1	·26	·02
Mosaic virus organisms . .	1	2	22

As direct evidence of the filterable forms of these organisms being the cause of the disease was unobtainable probably due to the virulence for plants being lost during the growth in vitro, indirect evidence was sought to prove the relation of the filterable forms to the virus producing the disease. For this purpose the virus (mosaic juice filtered through candle), the filterable forms of the organisms and the healthy juice (filtered through candle) were injected intravenously in successively increasing doses in rabbits and the serological reactions produced by these various antigens were studied. This brought out the close relationship between the filterable forms of the organisms and the virus.

If the serum produced by the virus or the filterable forms was mixed with the juice of mosaic leaves the virus was inactivated as evidenced by its failure to produce the disease in the two series of plants inoculated with the mixture while the mosaic juice mixed with serum produced by the organisms or the healthy juice failed to neutralize the virus as evidenced by the disease appearing in most of the twenty pots inoculated with the mixture. As the same mosaic juice was used for the above experiments, and had its own virulence separately tested, it is evident that the antibodies produced in the sera by virus and filterable organisms neutralized the virus. Thus the filterable forms of the organisms appeared to be similar if not identical to the virus.

Further the agglutination tests against the organisms also supported this conception :—

The results were confirmed by immunizing a fresh batch of rabbits which also gave similar results when sera were tested.

Complement fixation tests, Hemolysin reaction, and precipitation tests, also gave support to the agglutination results, and these in conjunction with the " in vitro " inactivation of the virus gave a strong support to the view that filterable forms and the virus were closely related.

Dilutions	1 : 100	1 : 300	1 : 400	1 : 800	1 : 1600	1 : 2400	1 : 3200	1 : 4800
Virus serum . .	++++	++++	++++	+++	++	+	...	...
Filterable form serum.	++++	++++	++++	++++	+++	++	+	...
Bacterial serum .	++++	++++	++++	++++	+++	+	...	...
Healthy juice serum.	+	+	...	...	...	...	...	..

The use of the immune sera for prophylactic purposes in plants was tried and it was found that these did not confer immunity ; further investigations are yet required to settle this point definitely.

F. *Chlorophyll changes.*— The relative amount of chlorophyll in healthy as well as mosaic leaves was studied at different times of the year in two varieties of sugarcane namely Co. 213 and Saretha, a local variety. This clearly showed that the plants recovered from the bad effects of mosaic from monsoon onwards. Thus the bad effect of mosaic on the yield is limited by the set back in growth during the periods of high virulence which are not very long under sub-tropical conditions. Further more, the experiment showed that climatic conditions have a major influence in determining the damage due to mosaic on the crop. This explained why the loss of tonnage due to mosaic varied in different years and why the reduction in yields was not so very great as in some other tropical countries. The relative percentage of chlorophyll in mosaic as compared to healthy leaves are given below :—

Date	13/7	4/8	5/9	20/9	17/10	27/11
Saretha . . .	69·7	74·8	86·1	93·4	97·4	95·2
Date	28/7	11/8	30/8	15/9	16/10	24/11
Co. 213 . . .	69·7	78·1	80·6	78·0	71·8	86·1

The estimations of chlorophyll were carried out by extracting equal areas of mosaic and healthy leaves in hot 85 per cent. alcohol under identical conditions. Equal areas of leaves were removed by punching out from the leaves of the same growth and age. The amounts extracted were compared in a Dubosque colorimeter.

Leaf to leaf variation of chlorophyll in mosaic and healthy leaves followed the same course. Topmost leaves were very poor in chlorophyll. Old dying leaves also showed little chlorophyll the functioning leaves were 2nd from the top to 9th. The 4th and 5th leaves had the highest amount of chlorophyll. The difference in the percentage in mosaic as compared to healthy leaves was most marked in 4th leaf in Co. 213 and 3rd leaf in Saretha.

G. *Tonnage experiment.*—The experiment on the effect of mosaic on the yield and juice of sugarcane was carried out at Pusa. Thirty-six plots, each 5 by 56 yards of Co. 213 were laid in adjacent pairs, half of them with mosaic-free and half with mosaic-infected canes in the order as follows :—

Mosaic-free, mosaic-infected, mosaic-infected, mosaicf-ree and so on. A very small amount of infection spread to the mosaic-free plots ; altogether seven clumps were affected by mosaic, seven

plots having one clump each. This very small spread to healthy canes in such close juxtaposition to mosaic-infected canes indicated how few and inactive insects were during the season in spreading disease. The mean percentage of infection with insects at the time of harvest was as follows :—

Mean percentage of infection

Insects	Mosaic-free.	Mosaic-infected
Top shoot borer	12·2	17·2
Stem borer	6·9	7·6
Root borer	13·2	13·3
Termites	7·9	7·8

The difference between the means was statistically significant in the cases of top shoot borer (odds 180 : 1) and stem borer (odds 42 : 1) but not in root borer and termites. No damage was caused by fungal diseases or by animals. After removing cane to eliminate edge effects the plots were five by fifty yards and the yield of stripped cane in maunds was as follows :—

Weight in maunds of stripped Co. 213

Plot	Mosaic-free	Mosaic-infected	Plot	Mosaic-free	Mosaic-infected
1 2	45·06	36·71	20 19	44·55	37·55
4 3	42·21	36·45	21 22	41·23	40·88
5 6	40·88	37·46	24 23	46·24	40·11
8 7	44·35	39·35	25 26	44·82	38·77
9 10	42·72	41·03	28 27	44·31	39·53
12 11	48·06	39·90	29 30	44·56	40·34
13 14	45·94	36·95	32 31	45·57	36·54
16 15	40·39	34·88	33 34	45·15	34·47
17 18	42·74	39·79	36 35	40·30	32·97
Mean .	43·84	38·00			

The mean difference 5·84 mounds or 13·3 per cent. is significant.

Difference 5·84 maunds or 13·3 per cent. is significant.

Randomized samples from all plots were analysed and the details of the statistical significance calculated by Student's method

of the difference in yield between the series of healthy and mosaic plots are summarised below :—

Co. 213	Mean difference (MF—M)	Standard deviation	Mean difference / standard deviation	Odds
Weight of cane . .	5·84	2·65	2·2	Very high.
Percentage juice to cane	·77	1·5	·63	70:1
Calculated juice per plot	4·30	2·1	2·05	Very high.
Brix	·10	·78	·04	0
Sucrose . . .	·24	1·13	·21	4:1
Glucose . . .	·04	·17	·023	0
Purity	·78	2·03	·38	14:1

The difference in weight of cane, percentage juice to cane, and calculated juice per plot were statistically significant. This season the differences both for top-shoot-borer and stem borer were statistically significant, so the difference due to borers has to be subtracted from 13·3 per cent. The loss in weight of cane bored by these two insects has been found by experience to be approximately 26 per cent. The loss due to both borers together is accordingly 4·96 per cent. in the mosaic-free and 6·45 per cent. in mosaic-infected plots. 43·84 maunds, the recorded mean weight of cane in the mosaic-free plots, represented 95·04 per cent. of the weight, if the cane had not been bored ; similarly 38 maunds represented 93·55 per cent. in the mosaic-infected plots. If there had been no borer attack the means of the weight of the two sets of plots would have been 46·12 and 40·62 maunds respectively. The difference of 5·5 maunds represents 11·9 per cent. and is approximately the loss in weight due to mosaic disease. The quality of juice as measured by brix, glucose, sucrose and purity was, however, not affected.

An experiment to see the effect of the mosaic disease in reducing the tonnage of Co. 213 sugarcane in South Bihar under irrigation and in a type of soil different from that of Pusa was carried out at Patna Farm in collaboration with Bihar Department of Agriculture. Twenty plots, each 44 yards long and 5 yards wide were laid out in adjacent pairs as at Pusa. Mosaic affected canes for the test were obtained from Pusa where the setts were selected at the time of harvest from plants whose leaves showed the usual symptoms of the mosaic disease. The mosaic-free canes were

carefully selected from the crop grown on the Patna Farm from plants whose leaves had no mottling.

The incidence of the insect attack was small and very little damage was done to the crop. The crop was free from disease excepting smut which appeared in a few shoots in April, 1933. The canes were harvested on the 17th of March, 1934. Edge effect was eliminated by cutting off two yards of cane growing at the ends of the rows and five lines of cane at the sides of the two end plots, thus leaving plots 5 × 40 yards in extent. The weight of stripped cane from each plot is shown in the table below :—

Weight in Maunds of stripped cane

F	M	F	M	F	M	F	M
1	2	35·44	28·18	12	11	37·44	29·85
4	3	32·05	29·95	13	14	38·29	31·20
5	6	35·46	27·85	16	15	37·82	31·55
8	7	34·38	26·49	17	18	38·58	30·26
9	10	35·82	28·49	20	19	34·68	27·10
		35·99	29·09				

Mean Difference 6·90

The mean of the mosaic-free plots is 35·99 while that of the mosaic-infected is 29·09 maunds. The difference of 6·90 maunds or 19·17 per cent. is statistically significant.

Randomized samples from all plots were crushed and analysed. The statistical significance of the differences in the various factors are summarised below :—

Co. 213	Mean difference (MF—M)	Standard deviation	Ratio	Odds
Weight of cane . .	6·9	1·7	4·0	Very great.
Percentage juice to cane	·16	1·5	·1	1·59 : 1
Calculated juice per plot	4·57	1·36	3·3	Very great.
Brix	·09	·51	·18	2 : 1

Thus the differences in weight of cane and calculated weight of juice to cane are statistically significant.

An experiment to find out the effect on tonnage and juice of Co. 213 sugarcane by mosaic disease was carried out by the Plant

Pathologist, United Provinces, at the Research Farm, Cawnpore, at the suggestion of the Sugarcane Mycologist. Six plots, each 90′ × 22½′ were laid out in adjacent pairs. Mosaic-infected canes for the test were obtained from Pusa and the mosaic-free canes from the Research Farm, Cawnpore. From the data kindly supplied by the Plant Pathologist, it is found that the mean of the mosaic-free plots is 49·74 while that of the mosaic-infected is 41·86 maunds. The difference 7·88 maunds or 15·9 per cent. was statistically significant.

A comparative statement showing the results of each of the three experiments is given below :—

Percentage loss due to mosaic

Place	In Tonnage	In calculated juice
Pusa	11·9	12·94
Patna	19·0	19·4
Cawnpore	15·9	17·08

It would appear from these results that the effect of mosaic in appreciably reducing the yield was marked and significant this year at various places and under different soil conditions. The reduction was more marked at Patna and Cawnpore Farms where the soil was irrigated than at Pusa where no irrigation was given.

III. CANE DISEASE

Red stripe disease.—The occurrence of this disease has been found on many varieties throughout India. The disease assumed minor importance and has not yet been recognised as a separate disease from top-rot into which the disease ultimately passes. In minor cases it occurred throughout Bihar in almost all varieties grown. Bengal and Assam Farms also had it in abundance. Isolations made from various localities agreed in their reactions and were found to be the strains of the organisms isolated last year. The biochemical reactions of these are distinct from those of *Phytomonas rubrilineans* Lee et al. and *Phyt. rubrisubalbicans* Christopher et al. The pathogenicity of these organisms has been established but it appeared that the virulence was not strong in many strains. It has been found to occur at the following places and in the undermentioned varieties :—

Gurdaspur—Co. 223, 300, 312, 313, 318, J. 213 and S. 48.

Lyallpur—Co. 223, 270, 287 and 318. Jullunder—Co. 343 and P. O. J. 2878 and "Mogul". Karnal—Co. 313 and Co. 384.

Ferozepur—Co. 213, 223, 262, 404, 1712, 6308, B. S. F. 12 (17), B. 6308 and Desi Ponda.

Padegaon—Co. 316 and P. O. J. 2878. Partabgarh—Co. 213, 300, 301, 312. Shahjahanpur—Co. 285, 312, 313, 331, 510, P. O. J. 2878 and C. S. varieties.

Stinking rot.—This is a new disease of sugarcane found during the year to cause serious damage in some varieties. It was first observed at the Sugarcane Research Station, Mushari, in Co. 300 and in Co. 313. The symptoms were wilting and rotting of the plant from the top downwards ; the whole stem became a mass of semi solid stinking pulp with a peculiar fermenting smell. The disease was found during the heavy monsoon months. The leaves were completely dried up in advanced cases. The leaves died as the nodes of origin disintegrated. The disease made a rapid progress from the inception to the end. Two bacterial cultures were isolated from the diseased tissues. Inoculations to prove the pathogenicity of these showed that while one was pathogenic the other was saprophytic, but the mixed culture of these bacteria made very rapid progress in causing the breakdown of the tissue and fermenting the cells with evolution of the typical smell. The infection took place during the monsoon and when the atmosphere was saturated with moisture for a length of time.

The biochemical reactions of the organisms were studied. Cultural characteristics pointed to the organisms being of the *pyocyaneus* group but the reactions differed markedly from *B. xanthochlorum* Schuster, *B. aptatum* Brown and Jamieson, *B. marginale* Brown etc., which are pathogenic to potato, beans and other plants. The organisms were motile with single polar flagella and did not form spores or capsules. They were non-pathogenic to potato, tomato, eggplant, capsicum and tobacco plants. No leaf spots or rot developed in these plants ; only local points of infection dried up and the plants remained healthy.

The probable point of entry of the organisms in the plants is supposed to be through top shoot borer holes, the " dead heart " forming a suitable ground for mass development. When the rot developed it killed the plant within a fortnight. Stray cases were observed at Pusa in Co. 313. The isolations made proved to be similar to those obtained from Mushari. The disease was also observed at Shahjahanpur in Co. 312 (G. C. Serial Nos. 67 and 49) and was quite conspicuous. Organisms with similar characteristics have been isolated from these specimens, but their pathogenicity has yet to be tested.

Ustilago scitaminea Syd. was recorded in the following varieties at Karnal (Punjab) :—Co. K2, K_6, K_7, 213, 290, 313, 317, 318, 319, 327, 331, 356, 369, 384, 385, 391, 396, 400, M. 49881, 54723, 57514, 58229, Katha, Dhaulu of Batala, Lalri and on C. S. 5 (213 × 244) and Co. 401 at Shahjahanpur.

Cercospora longipes Butl. was recorded on the following varieties in severe form at Karnal :—

Ck. 11, 12, Co. 285, 300, 320, 321, 325, 343, 345, 366, 368, 371 372, 374, 377, 379, 382, 390, 391, M. 44797, 49881, 54723 and 58224

Thielaviopsis ethaceticus Went. was found in "Poovan" at Coimbatore, S. India. The symptoms of the disease were similar to those of wilt. The leaves dried up as in the case of drought from tips and the whole cane wilted. In early stages on cutting open the stem the core was found to be reddened, but on incubation it turned sooty black with macrospores of the *Thielaviopsis ethaceticus*. At this stage the characteristic odour of pineapples was noticeable. A culture was obtained. The pathogenicity of the fungus was established and its morphology was studied. The perfect stage, *Ceratostomella paradoxa* (de Seynes) Dade appeared in the culture.

A new seedling disease was observed at Coimbatore. The seedlings were found to die in great numbers in pans where sugarcane seeds were planted. The yellowing of the leaves was first noticed and this was followed by wilting of the plants. On investigating the cause of this trouble the roots were found to be discoloured and brittle. In some infected cases the dark brown discolouration of the leaf sheath was prominent. The symptoms of the disease were like those of 'Foot rot' caused by *Helminthosporium sativum* P. K. and B. in wheat. A species of *Helminthosporium* was isolated from diseased seedlings. Infection experiments were carried out to prove its pathogenicity in Co. 414, 419, 420, B. 3412, M. 16 and Lalgira, it was found to infect both upper and under surfaces of leaves. The characteristic leaf spot developed in all the varieties. The inoculations made at the foot of the tillers from various varieties showed that the fungus was infective and parasitic only under excessive moisture conditions of the soil.

The study of the top-rot caused by *Fusarium moniliforme* Sheld. was continued, isolations made from various places have been tried for their virulence and pathogenicity. One strain isolated from Dacca differed in cultural characteristics from those of a strain isolated from Pusa.

Fusarium strains were isolated from cases of top-rot in jowar, but they failed to infect sugarcane and their virulence for jowar itself was limited. Maize also failed to take up the infection. *Fusarium* strains isolated from sugarcane were introduced into jowar and maize and it was found that they were not pathogenic for these crops.

In July 1933 the top-rot disease caused by *Fusarium moniliforme* was much in evidence in the farm on Co. 210, 213, 299 and

tonnage plots in mosaic experimental area. Experiments for controlling the disease by spraying colloidal sulphur were carried out. 100 diseased plants were marked and dusted with RV_3 Sulphur, 100 marked diseased plants left over to serve as control and 100 healthy marked plants were kept under observation. At the harvesting time following observations were made :—

	Healthy plants	Died attacked by white ants	Died-shoot borers	Total
Treated with RV_3 S. .	63	19	18	100
Control, diseased . .	69	15	16	100
Healthy	83	6	11	100

The results indicated that the plants recovered from the disease of their own accord and that dusting with RV_3 Sulphur had no beneficial effect in particular. The disease weakened the plants which fell an easy prey to white ants and shoot borers ; the loss thus engendered was nearly 17 per cent. in number of plants.

IV. PROGRAMME, 1934-35

1. Cultivation of mosaic virus in vitro and problems developing therefrom. 2. Study of physiological and histological changes in the sugarcane brought about by mosaic disease. 3. Effect of various physical and chemical factors on virulence of mosaic virus. 4. Tonnage experiment on effect of mosaic on Co. 213. 5. Varietal test experiment to see the natural spread and resistance in different varieties. 6. Masking and elimination of mosaic under natural conditions. 7. Investigations on red stripe and stinking rot diseases 8. Physiological studies on *Cephalosporium sacchari* Butl., *Fusarium moniliforme* (5 strains), *Thielaviopsis ethaceticus* Went. [=*Ceratostomella paradoxa* (de Seynes) Dade], *Colletotrichum falcatum* Went., *Ustilago scitaminea* Syd. and *Helminthosporium* sp. causing foot rot of seedlings.

V. ACKNOWLEDGMENTS

Thanks are due to Dr. S. S. Sokhey and Dr. Wagle, Director and Bacteriologist respectively of the Haffkine Institute, Bombay, for their keen interest and help in carrying out the serological reactions under their supervision.

VI. PUBLICATIONS

I.	Desai, S. V.	Nature of viruses. (*Poona Agricultural College Magazine*, Vol. 25, No. 3, December, 1933).
II.	McRae, W. & Subramaniam, L. S.	Effect of mosaic disease on the tonnage and the juice of sugarcane in Pusa, Part IV. [*Ind. J. Agri. Sci.* Vol. IV, Pt. V, Oct. 1934, pages 787—796.]
III.	Sarkar, B. N. & Dutt, K. M. .	Effect of mosaic disease on the tonnage and the juice of sugarcane in Patna. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. V, Oct. 1934, pages 796—802.]

REPORT OF THE IMPERIAL ENTOMOLOGIST

(P. V. Isaac, B.A., D.I.C., M.Sc.)

I. ADMINISTRATION

I held charge of the section throughout the year in addition to my own duties as Second Entomologist (Dipterist).

Rai Bahadur C. S. Misra, Assistant Entomologist, was on leave on average pay until 2nd July 1933 and again from 19th to 31st January 1934.

The second Assistant Entomologist's post sanctioned during the year 1932 has not yet been filled.

Mr. H. L. Bhatia, Assistant, left Pusa on 1st March 1934, to take up an officiating appointment in Class II for ten months under the Director, Imperial Institute of Veterinary Research, Muktesar, and remained away for the rest of the year.

II. TRAINING

Mr. Hira Nand Batra, B.Ag. Post-graduate student, was under training during the year.

Mr. E. J. Vevai, B.Ag. (Bombay), Post-graduate student, was admitted on 2nd November 1933 for training.

III. INSECT PESTS

Sugarcane

Definite observations were made on the bionomics of *Scirpophaga nivella* Fb., the sugarcane Top-shoot borer. It was found that the borer hibernated in cane as larvæ till the third week in February. Pupation began in the last week of February. The first moth was noticed to emerge on the 28th February.

The following table gives the number of egg-masses laid on a sugarcane experimental plot of 2·5 acres.

Month	Number of egg masses	Area of plot
		Acres
February 1934	*Nil*	2·5
March 1934	497	2·5
April 1934	205	2·5
May 1934	575	2·5
June 1934	74	2·5

Final examination of the crops of cane covering an area of 1·95 acres was made from 17th March to 11th May 1934 to determine the incidence of the major pests of sugarcane. The examination was facilitated as the sugarcane had to remain in the ground till the end of May as the cane factories in the neighbourhood had been severely damaged by the earthquake on the 15th January 1934. In all 16,469 canes were examined. It was found, that the percentage of healthy canes in both the crops where canes were grown without any irrigation varied from 21·10 per cent. to 45·41 per cent. The percentage of infestation by the Top-shoot borer, *Scirpophaga nivella* Fb. varied from 11·55 per cent. to 35·37 per cent. The percentage of the three stem-borers, *Chilo zonellus* Swinh., *Argyria sticticraspis* Hmp. and *Diatræa venosata* Wlk. together varied from 2·33 per cent. to 8·01 per cent. The percentage of damage by the root-borer, *Emmalocera depressella* Swinh. varied from 3·2 per cent. to 11·55 per cent. The percentage of infestation by Termites was low and varied from 1·48 per cent. to 7·82 per cent.

During April and May the number of adult *Pyrilla* spp. present on sugarcane planted in February was insignificant. By the middle of June the number of adults increased and oviposition on a large scale took place. In the beginning of August large numbers of eggs were laid and the parasitization of eggs varied from 52·5 per cent. to 68·7 per cent. By the end of September the parasitization reached as high as 94·9 per cent. Thereafter it declined, and eggs were laid mostly in sheathing leaves from October onwards. By the end of October considerable number of nymphs were parasitized by *Dryinus pyrillæ* Kieff. and *Chlorodryinus pallidus* Perkins.

Of late, the yellowing disease of sugarcane leaves has attracted much attention in the sugarcane growing tracts of North Bihar. During the year under report, a large number of plants in the experimental plot were affected by this disease. Investigations have been begun to find out the causative agents of this disease.

Co-operation was given to the Mycological Section in the investigation of sugarcane mosaic disease. The tonnage experimental plot was under constant observation and efforts were made to keep the insect pests in check in the plot throughout the year. The egg-masses of the Top-shoot borer *Scirpophaga nivella* Fb. were collected and destroyed, and dead hearts and damaged shoots were removed.

At the time of harvest during the end of February and in the beginning of March the percentage of damage by *Scirpophaga nivella* Fb., by stem-borers, by the root-borer, *Emmalocera*

depressella Swinh. and by termites in the Tonnage experimental plot was found to be as detailed below :—

	Scirpophaga nivella Fb. (Top-shoot borer)	Stem borers	*Emmatocera depressella* Swinh. (root borer)	Termites
	%	%	%	%
Co. 213 Mosaic-free canes.	12·22	6·9	13·16	7·91
Co. 213 Mosaic-infected canes.	17·25	7·6	13·28	7·85

Other pests

Diacrisia obliqua Wlk. was very bad on *til* (*Sesamum indicum*) and potato plants in beds. *Prodenia litura* Fb. and *Plutella maculipennis* Curt. damaged early planted cauliflowers. *Ergolis merione* Cram. was exceptionally bad on castor leaves. *Dysdercus cingulatus* Fb. and *Oxycarœnus lœtus* Kby. were present in numbers on *bhindi* (*Hibiscus esculentus*). *Athalia proxima* Klug. appeared in large numbers on mustard, radish and other Cruciferae. *Maruca testulalis* Geyer and *Lamprosema indicata* Fb. were found in large numbers on *Urad* (*Phaseolus radiatus*) pods. *Prodenia litura* Fb., *Heliothis* (*Chloridea*) *obsoleta* Fb. and *Gallobelicus crassicornis* Dist. appeared in large numbers on tobacco seedlings. *Utetheisa pulchella* Linn. and *Etiella zinckenella* Tr. did much damage to sann-hemp pods. *Maruca testulalis* Geyer. did considerable damage to velvet beans. *Chilo oryzœ*, *Nephotettix apicalis* Motsch. and *Nephotettix bipunctatus* Fb. appeared on rice, the two latter when it was in ears.

The worst attack during the year under report was that of *Agrotis ypsilon* Rott. on peas, gram, linseed, tobacco and cruciferous plants. Considerable damage was done particularly to peas, mustard and linseed crops. Hand picking trenching and poisoned baits were adopted. Flooding the affected area brought out the caterpillars to the surface and these were destroyed by birds that came down in swarms and quickly cleared the infested fields. The pea stem Agromyzid damaged a large number of plants in experimental plots. Light spraying with naphthaline emulsion had considerable effect on unrestricted oviposition. *Dichochrocis punctiferalis* Gn. damaged guava fruits both ripe and unripe. *Virachola isocrates* Fabr. also attacked guava fruits. *Amblyrrhinus poricollis* Boh. considerably damaged mango trees when these put forth new vegetative growths. *Nodostoma subcostata* Jac.

nibbled the skin of plantain fruits and made them unsightly. There was a mild attack of *Myzus persicæ* Sulz. on peach. Spraying with Nicotine sulphate was found to be effective. *Papileo demoleus* Linn. appeared on *Citrus* spp. Timely spraying with Lead arsenate and hand picking checked it completely. *Spodoptera mauritia* Boisd. was reported doing damage to paddy crop in Chakni, Champaran. Vulnerable points in its life-history and control measures were suggested. Rice stem-fly was reported to do considerable damage to paddy crop in Balasore and Sambalpur districts. Remedial measures were suggested.

Wire-worms (grubs of *Elateridæ*) damaged lentil crop in Bhopal. Control measures were suggested.

In the Insectary the life-histories of forty insects of different orders were studied partly or fully and both coloured and black and white illustrations were prepared to record the results obtained. The following are the more interesting ones :—

A female moth of *Dinara combusta* Wlk. was captured and it laid eggs on 1st August 1933. The larvæ were fed on maize leaves. They were fully grown by September 1933, when they pupated. The moths emerged in June 1934. Hibernation takes place in the pupal stage which is of nine and a half months duration.

One Asilid fly maggot *Philodicus* sp. was found in moist soil on October 20, 1933. The maggot pupated on 20th March 1934. The fly emerged on 15th April 1934.

During the year under report investigation on the probable transmission of the crinkly leaf disease and the yellow mosaic disease of tobacco by insect agency was carried on in the Insectary. No conclusive results could be obtained as the work was interrupted by the recent earthquake.

Experiments were started to try control measures against cockroaches. Various insecticides such as sodium flouride, borax, sodium fluosilicate, boric acid and copper carbonate are being tried to find out their relative efficacy to bring under effective check this obnoxious insect. Both stomach and contact poisons are being used. The results are not yet conclusive.

Investigation of Insect pests causing damage to the fruit trees in the Fruit Experimental Station, Quetta, and other fruit growing areas in Baluchistan was continued during the year under report. Numerous larvæ and pupæ of the codling moth *Carpocapsa pomonella* Linn. were seen causing damage to the apple trees at Quetta. At Fort Sandeman the pest was noticed infesting apples and pears. Grubs of *Aeolesthes sarta* Solsky, the "Quetta Borer," were collected from cherry and apple trees at Quetta. The presence of the grubs was indicated by the drying up of the terminal twigs and branches of the affected trees. Black Peach Aphid *Lachnus persicæ* Cholodk. was doing considerable damage to peach

trees in and around Quetta. At Fort Sandeman and Wiarat, apple foliage were severely infested by the larvæ of the Tortricid *Cacœcia pomivora* Meyr.

Surra disease broke out in the Government Dairy Farm, Karnal. A fieldman was sent on tour to collect biting flies associated with the disease and to locate their breeding grounds within the area of the Government farm. He prepared a map of the farm marking the actual and potential breeding grounds of *Tabanus* and other biting flies. Two kinds of Tabanid larvæ were collected from there and were reared in the Laboratory at Pusa and found to be examples of *Tabanus virgo* Wied. and *Tabanus tenens* Wlk.

The control of mosquitos on the Pusa Estate received constant attention. All breeding places were treated as far as possible. To guard against the breeding of *Stegomyia* the tree and bamboo holes near residential buildings were filled with earth.

A new fly-trap was experimented with and was found very effective to control house flies.

IV. BEES AND LAC

Apiculture.—Numerous inquiries were received and information and assistance was given as far as possible. There was an increasing demand for artificial comb foundations for *Apis indica* Linn. These were prepared in the laboratory on the comb foundation machine. Zinc queen excluders were supplied to several correspondents. Artificial standard hives prepared by a local carpenter were also supplied to some correspondents.

Lac.—The main crop of lac was adversely affected by the heat in June 1933. This did not revive well in the following October, with the result that the main crop in June 1934 was again a poor one.

V. INSECT SURVEY

Collections were sent out for identification to the following specialists and their help is gratefully acknowledged :—

Larvæ of nine different Curculionidæ to Forest Entomologist, Dehra Dun.

Cecidomyiidæ to Director, Imperial Institute of Entomology, London.

Coccidæ to Mr. F. Laing, British Museum, London.

Thysanoptera to Dr. Ramakrishna Ayyar, Coimbatore, Madras.

Fruit pests collected from Quetta and other places in Baluchistan and other miscellaneous specimens to the Director, Imperial Bureau of Entomology, London.

Psyllidæ to Mr. D. L. Crawford, California.

Microlepidoptera to Imperial Institute of Entomology, London.

Isoptera to Imperial Institute of Entomology, London.

Lucanidae to Mr. G. J. Arrow, London.

Gryllidæ to Imperial Institute of Entomology, London.

Cerambycidæ to Forest Entomologist, Dehra Dun.

Aphididæ to Mr. F. Laing, British Museum, London.

Indian Insects were suplied to certain correspondents as listed below :—

Tabanidæ and *Oestridæ* to the Government Entomologist, Lyallpur, Punjab.

Specimens of *Schizodactylus monstruosus* Dr. including adults and nymphs of different stages to Mr. Kjell Ander, Zoological Institute, Lund University, Sweeden.

Arctiidæ to Government Entomologist, Coimbatore, Madras.

Ichneumonidæ to Government Entomologist, Coimbatore, Madras.

Specimens of *Gastrophilus equi* Clark. to the Principal, Veterinary College, Madras.

Orthoptera to Government Entomologist, Lyallpur, Punjab.

Four specimens of *Aswathamanus cylindricus* Kirb. to the Director, Colombo Museum, Ceylon.

Calliphorinæ to W. S. Patton, Liverpool, London.

Collections of Indian insects were received from sixty-one correspondents. These were named and returned as far as possible.

VI. PROGRAMME OF WORK FOR 1934-35

Major

This will follow generally on the lines of work of the current year and will include general investigations of crop pests and other injurious insects and especially of the pests of sugarcane, fruit trees and stored grains and domestic animals.

Minor

Results in various lines of work require to be written up and published as far as possible. New insecticides and control methods will be tested as occasion arises. Systematic work will be carried on with our resources and the help of specialist correspondents. The Catalogue of Indian Insects will be proceeded with. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

VII. PUBLICATIONS

The following publications prepared by the staff have been issued during this year :—

Bhatia, H. L. . . .	A note on the Life-history of *Psilocephala sequa*, Wlk. (Fam. *Therevidæ*). *Ind. J. Agric. Sc.* **4**, *203*.
Fletcher, T. Bainbrigge .	Life-hostories of Indian Microlepidoptera, Second series. *Cosmopterygidæ* to *Neopseustidæ*. *Sc. Mem.* 4, *Imp. Coun. Agric. Res.*
Isaac, P. V. . . .	The life-history and seasonal abundance of the vesicating beetle *Pœderus fuscipes* Curt. *Ind. J. Agric. Sc.* **4**, *200*.
	Papers on Indian Tabanidæ, X. The life-history of *Tabanus speciosus* Ric. *Ind. J. Vet. Sc. Anim. Husb.* **3**, *182*.
Isaac, P. V. and Misra, C. S.	The Chief Insect pests of sugarcane and methods for their control. *Agric. and Live-stock in India*, **3**, *315*.
Narayanan, E. S. . .	Biological control of insect pests and the possibility of utilising *Trichogramma minutum* Riley in India for the control of sugarcane borers. *Agric. and Live-stock in India*, **3**, *459*.

REPORT OF THE BACTERIOLOGICAL SECTION

(N. V. Joshi, B.A., M.Sc., L.Ag.)

I. ADMINISTRATION

I held charge of the section throughout the year.

I was on leave on average pay for 9 days from 2nd January 1934.

Mr. C. S. Rama Ayyar, Third Assistant Bacteriologist, was granted privilege leave for one month and twenty-eight days, combined with furlough on half average pay for two months and twelve days from 2nd June 1934.

II. TRAINING

There was no admission of post-graduate students during the year.

III. SOIL BACTERIOLOGY

Conservation of Nitrogen in soil.—The series of rotation experiments started four years ago to test the influence of leguminous crops on the conservation of soil nitrogen were continued. The figures for total nitrogen remaining in the soil at the end of the last harvest were, in the *kharif* (summer) series of plots lower than at the beginning of the experiments but in the *rabi* (winter) series plots, they were higher excepting one, the maize—barley rotation. Taking into consideration, however, the nitrogen removed by the crops, a gain in nitrogen is found in all the plots of both the series. The highest gain calculated in this way is 415·8 lbs. per acre in the *kharif* series with the mixed crop of maize and *urid* and 364 lbs. in the *rabi* series with the mixed crop *kerao* and barley.

The plots in both the series can be placed in two different orders according to (*a*) the observed gain in nitrogen in the soil and (*b*) the economic value of the crops produced during the last years under experiment. A careful statistical analysis is being made of the yields obtained as well as the nitrogen gained by the soil to ascertain which system of cropping is superior from both the points of view.

Nitrification.—The experiment started to find the seasonal effect on nitrifying flora in soil taken from field and in soil kept in the laboratory was continued. The changes in the seasonal

temperature appear to affect the nitrifying flora to a great extent and cause two periods of depression in May and November while the changes in moisture content cause comparatively minor variations in the nitrifying activity of the soil.

Bacteriological examination of soils from permanent manurial experimental plots.—The examination of samples of soil taken every three months from the permanent manurial experimental plots Nos. 3, 10, 12, 13 and 16 in the Punjab field was continued.

The nitrifying power of these samples was tested with *sarson* cake and ammonium sulphate as the material to be nitrified. The samples taken in June and December were comparatively richer in nitrifying organisms. The June samples nitrified both *sarson* cake and ammonium sulphate completely in 4 weeks and December samples took 8 weeks for complete nitrification. of ammonium sulphate but could nitrify only about 75 per cent. to 80 per cent. nitrogen of the *sarson* cake. During the same period the March and September samples were not able to nitrify more than 85 per cent. of the nitrogen contained in ammonium sulphate and 55 per cent. of the nitrogen contained in *sarson* cake. This indicates that there is either a difference in the numbers of the nitrifying organisms or a variation in the ratio of the nitrifiers to non-nitrifiers resulting in the varying nitrifying power of the soil in different seasons.

The comparison of the figures for the numbers of bacteria per gram and the percentage of the total nitrogen content of these soil samples with the figures of those taken in the previous year shows a difference in favour of the 1933 samples. It is not as yet known whether this is exceptional for the year or whether such annual increases and decreases in numbers of bacteria and in nitrogen content of the cultivated soils form a normal feature besides the regularly observed seasonal variation.

Decomposition of cyanamide in soil.—Last year it was reported that the chemical methods to be used in determining the course of decomposition of cyanamide were standardised. These were applied to Kalyanpur soil this year. Further work could not be undertaken after the earthquake owing to want of laboratory accommodation and insufficient pressure of water for filtration and distillation.

Bacteriological analysis of soils.—Bacteriological analysis of Pusa soil under irrigation and dry farming condition was continued. The number of bacteria and the total nitrogen were observed to be higher in irrigated plots than in unirrigated plots but as there is no marked difference in the ammonifying, nitrifying and nitrogen-fixing power between the soils from the irrigated and unirrigated plots since the experiment was started in 1934 it is

assumed that the changes in bacterial flora occurring after irrigation of soil are too slow to be discovered under Bihar conditions and it is proposed to discontinue the experiment.

Samples of the sand and silt thrown out by the recent earthquake were collected and a study of the bacteriological activity in these and the normal Pusa soil was made to get an idea of their fertility as compared with the normal Pusa soil. Slides put in the various silts and sands showed comparatively fewer organisms than in Pusa soil. The table below gives the average of pH indices and nitrogen content.

	pH	Total nitrogen per cent.	Number of organisms per gram	N. nitrified Omelianski's solution in 8 weeks
Silts	8·4	·052	660,000 4,380,000	40 to 80 per cent.
Sands	8·8	·032	484,000	30 per cent. up to nitrated stage.
Pusa	8·1	·084	4,860,000	100 per cent.

The figures are the average of duplicate of four samples of each and show that the difference between the silts and the normal Pusa soil is not very great while the sands are poorer in nitrogen and nitrifying flora.

Green manures.—The field experiment started two years ago to compare the value of sann-hemp with *urid* and sann-hemp tops applied later in the season so as to secure the stems for getting fibre out of them was continued. The treatment of plots was retained the same as last year's, in order to bring out the fact that in spite of the original low fertility of the plots used for the treatment, where sann-hemp fibre is taken out and only the tops applied as manure, gives the highest net profit per acre of all the treatments.

The net profit reported after meeting cost of production for the years 1932-33 and 1933-34 are as under.

Treatment	1932-33 Average net profit per ¼th acre	1933-34 Net profit per ¼th acre
	Rs. A. P.	Rs. A. P.
T_1 Wheat after maize	22 14 9	7 15 7
T_2 Wheat manured with *urid*	14 11 2	8 14 8
T_3 Wheat manured with sann-hemp	12 2 2	13 2 3
T_4 Wheat manured with sann-hemp top and fibre extracted from the stems.	9 4 4	15 10 8

The average net profit reported is the average of four plots of 1/16th acre each. Last year it was reported that the plots used for the last treatment (T_4 in the table) were very low in fertility and had shown the least profits in the year 1931-32 in which year they were under the first treatment (T_1 wheat after maize). The fact that this year in spite of this initial low fertility, the net profits per acre in these plots are the highest of all the other treatments shows how great the improvement in the fertility of the soil is effected under the treatment of green manuring with sann-hamp tops and getting the fibre from the stems.

A similar experiment on plots of 1/5th acre and Latin square lay out with five treatments and five replications was carried out on the farm and the results reported as follows :—

Treatment.	Value of produce *minus* cost of cultivation	
	1931-32	1933-34
	Rs. A. P.	Rs. A. P.
T_1 Fallow wheat	29 2 4	24 13 9
T_2 *Urid* green manured wheat . . .	22 6 7	15 10 11
T_3 Soybean green manured wheat . . .	23 7 4	22 5 10
T_4 Sann-hemp green manured wheat . . .	35 4 9	40 2 2
T_5 Sann-hemp tops buried, fibre extracted from stems and wheat.	30 8 3	48 13 7

The examination of the two years' results shows that the treatments T_4 and T_5 give best profits and that there is a very keen competition between the two treatments and the next year's results are awaited with interest. Under T_5 treatment the yield of fibre obtained from the stems more than compensates the labour involved in extracting it and the slightly lower yield of wheat obtained than in treatment T_4 where sann-hemp is buried.

The experiment on growing Mexican sunflower (*Tithonia diversiflora*) with onions and burying the Mexican sunflower as green manure was again carried out this year. The results show that control plots with onions alone yielded on an average 125·9 maunds per acre ; the plots with onions and Mexican sunflower yielded 116·8 maunds of onions per acre and only 93 maunds of sunflower. This low yield of sunflower is due to the fact that sunflower could not be planted at the proper time in the middle of January owing to the disturbance caused by earthquake. Moreover sand and silt were thrown out in small fissures in these plots and irrigation

also could not be given as frequently as was described. The 93 maunds of Mexican sunflower obtained was buried in June 1934 in the same plots in which it was grown, and the yield of crops grown on the plots in the *kharif* and the *rabi* seasons of 1934 will be compared next year.

The yields of crops grown in plots of the previous experiments (1932-33) on growing Mexican sunflower with onions have shown increased yields of maize and wheat after burying the Mexican sunflower as green manure, but the question whether it is economic to do so has not yet been definitely established.

Manurial value of Katwa sewar.—*Katwa sewar* is an acquatic plant growing abundantly in the river beds. It has been found that it ferments very easily in the soil and supplies humus to soils and as such it is likely to prove useful for applying as manure in Indian soils which are known to be poor in organic matter. Some preliminary experiments were carried out to test its value in comparison with farm yard manure. The yield of maize (average of four plots) with farm yard manure was 8 maunds 26 seers per acre while with sewar it was 12 maunds 20 seers per acre showing an increase of 44·5 per cent. The economics of this manure will be worked out next year by statistical analysis.

Manuring experiment with potatoes.—In order to see what effect the application of different manures has on the keeping quality of potatoes it was necessary to grow the potatoes in manured plots. Comparison of yields of the plots under different manures for the last three seasons was found to be interesting showing that the *sarson* cake was the best manure for potatoes. The results were examined by the method of Fisher's analysis of variance, and were found to be highly significant. The important conclusions of the analysis are summarised in table below :—

Treatments	Mean yield in lb. per acre	Critical difference
T_1 Mustard cake	7187	583·7 at 5 % level. 778·0 at 1 % level.
T_2 Farm yard manure and superphosphate	5688	
T_3 Farm yard manure	5241	
T_4 Sodium nitrate	5621	
T_5 Superphosphate	4388	
T_6 Ammonium sulphate	4801	
T_7 Potassium sulphate	3797	
T_8 Control	3771	

$$T_1 > T_2\ T_3\ T_4\ T_5\ T_6\ T_7\ T_8$$
$$T_2 = T_4 > T_5\ T_6\ T_7\ T_8$$

A paper is being written on the subject.

Dissociation of B. cereus.—Study of the dissociation forms of *B. cereus* which is frequently associated with the mosaic disease of tomatoes and other vegetables as well as of tobacco was continued. Another variant was found on plating of old broth cultures of this organism. The peculiarity of this variant is that it does not form spores and its colonies are free from the usual pellucid dots which is one of the chief characteristics of the normal cultures of *B. cereus*. No previous description of such a variant of B *cereus* is found in the bacteriological literature studied and this is the first time that the existence of such a variant of *B. cereus* without the pellucid dots is recorded. This variant was not detected earlier because it could not be isolated from the agar cultures, which were studied and used for plating, since the cells of this variant of *B. cereus* occur in such small numbers in old agar cultures that they are crowded out by the colonies of the usual pellucid dot variant. In old broth cultures the percentage of cells of this variant is very high and hence when old broth cultures are plated out the colonies of this variant can be easily observed on the plates.

Previous workers have concluded that the pellucid dots observed in *B. cereus* cultures are the result of the association of a lytic principle with the bacterial cells, the dots being regarded by them as lysed spots. This conclusion of theirs is no doubt based on the consideration that they were not able to isolate a cultural variant of *B. cereus* without the pellucid dots and therefore they imagined that such a variant could not exist.

Work carried out in this section and reported last year had already shown that no lytic principle could be isolated from the cultures of *B. cereus* with pellucid dots, and hence these dots were then considered to be the result of the dissociation of the cultures into different types, although direct proof by the production of pellucid dots by growing the dissociated variants together was lacking at that time. After the isolation of the cultural variant without pellucid dots this year, it was possible to obtain direct evidence on this point. This new variant was grown in separate tubes in association with each of the other variants already isolated from the cultures of *B. cereus*. The associated growth of the new variant with (1) the Coccal rod variant and (2) the Coccus variant gave rise to the pellucid dots exactly similar to the normal *B. cereus* cultures. The associated growth with other variants produced no change.

It has been already observed that the cultures of *B. cereus* with pellucid dots when grown only from spores in successive transfers always dissociate into several variant types. The cells of these types are spread at random in the agar culture at first, but when certain particular variants come together and grow in

close proximity to each other, the pellucid dots having the appearance of lysed spots are formed owing to a difference in the transparency of their growths. The origin of the pellucid dots in the normal cultures of *B. cereus* is thus to be traced to its dissociation into cultural variants with growths of different transparency.

The filterable forms of *B. cereus* have also been observed and the conditions under which they remain stable, have been discovered and their stabilisation has been effected. The results of this study are being written up for publication.

IV. DAIRY BACTERIOLOGY

The average plate counts of the bacterial content of the Pusa milk supply are given below with those of the previous two years.

Months	Average counts per etc.		
	1931-32	1932-33	1933-34
July	3,833	5,225	13,200
August	4,092	7,857	6,843
September	4,753	10,575	8,611
October	2,333	13,760	5,249
November	3,490	7,713	6,563
December	3,400	4,098	10,077
January	8,825	6,508	5,336
February	4,000	3,617	4,625
March	9,750	5,071	5,882
April	8,617	3,717	7,050
May	5,871	5,127	10,629
June	7,192	8,283	7,290

In the first half year except in July the counts were lower than those of the preceding. In the latter half the counts are higher except in June. This is due to the damage caused by the earthquake in January to the milk collecting room provided with wire screens and the flies getting access to milk without proper control. In spite of this defect the counts were not very high even in April and May when the flies were numerous and could not be controlled by the fly traps.

The table below shows the number of *B. coli* present in the afternoon dairy milk supply at Pusa.

Month	Number of occasions when *B. coli* was observed			Total number of days in which determination was made
	1 c. c.	1/10 c .c.	1/100 c. c.	
July, 1933 . . .	..	12	6	13
August . . .	..	13	12	14
September . . .	..	7	*Nil*	9
October . . .	1	*Nil*	*Nil*	11
November . . .	4	2	*Nil*	12
December . . .	5	4	..	9
January, 1934 . .	11	3	..	11
February . . .	11	5	..	12
March	3 out of 3	10	..	11
April	..	12	5	13
May	..	7	*Nil*	14
June	..	9	4	12

Types of coli organisms.—250 cultures from colonies selected at randon from the plates made from Pusa milk were examined. Of these 13 or about 5·2 per cent. did not ferment glucose and therefore do not belong to the coli group. 148 or 59·2 per cent. belonged to the *Aerogenes Cloacæ* group. The rest, *i.e.*, 45·6 per cent. belonged to the coli group. In July organisms of *Aerogenes Cloacæ* group only were present. In August and September, the ratio of *Aerogenes Cloacæ* group to coli group was 70 : 30 and 58·5 : 41·5, respectively. The importance of the determination of this ratio will be apparent when it is realised that while the presence of *Aerogenes Cloacæ* group organisms indicates no fæcal contamination, the presence of *B. coli* in large numbers indicates fæcal contamination.

A series of fresh experiments on the use of Catadyn water was carried out to determine the germicidal value of the water passed

through catadyn pellets and its use in dairy practice to render dairy utensils free from contamination with *B. coli* and similar harmful organisms. The results have shown that catadyn water, if it is to prove effective, has to be passed through catadyn pellets immediately before use. It was found to retain its efficiency if stored in glass vessels for some hours (12 to 18 hours), but if stored in metal vessels it loses its efficiency much earlier than when stored in glass vessels. It cannot replace the washing of dairy utensils with soda as it cannot dissolve the thin layer of the milk-fat on the sides of the vessels. It is effective in killing the *B. coli* germs that remain attached to the vessels after cleaning with soda and soap. It can, therefore, replace steaming or chlorine disinfectant. The time of contact of catadyn water with glass bottles is required to be from 2 to 4 hours (according to the degree of contamination), in order to kill all coli organisms likely to be associated with such bottles. In the case of metal vessels 6 to 8 hours contact with catadyn water is found to be necessary. To be safe, the longer period of contact is to be preferred with both kinds of vessels. Whether it is possible to allow so much time, *i.e.*, 6 to 8 hours for the dairy utensils to remain in contact with catadyn water will depend on the number of times of milking in the dairy and the kinds of vessels to be dealt with. If milking for 3 or 4 times is practised, as is done at Pusa two sets of milking cans will have to be provided if catadyn water is to be regularly used in practice in place of steam.

V. SILAGE

In previous years it has been found that some fodder plants such as berseem, kudzu vine and *dhub* grass (*Cynodon dactylon*) if ensiled by themselves do not yield a good silage ; and that the addition of wheat or oat straw or molasses results in improving the product obtained after ensiling. A study of the changes in bacterial population of the different materials during the course of ensilage was made and it has been ascertained that the organisms of *Aerogenes Cloacæ* group are predominant in the early stages when berseem, *dhub* grass or kudzu vine are ensiled by themselves, *Streptococcus lactis* appearing only in later stages. When wheat straw or molasses are added, the predominant organism present from the start is *Streptococcus lactis*.

This difference in the kinds of organisms present in the initial stages of fermentation appears to be dependent on the kind of food available for the bacteria present in the ensiled materials and is of great importance in governing the kind of fermentation set up. This observation places at the disposal of the agriculturist a useful means of getting a good quality of silage from the materials which are available in abundance but do not yield a satisfactory product

when stored in the silage pit. What is required to be done is merely a suitable alteration of the composition of the material to be ensiled. This can be attained by the addition of surplus materials like wheat and oat straw or molasses which are at present running to waste in many sugar mills.

VI. POTATO STORAGE

Country potatoes grown after application of different manures were stored in March 1933 to see the effect of manuring on the keeping quality of potatoes. The potatoes were stored with and without charcoal for comparison. When taken out from storage in October 1933 almost all the tubers were found to be well preserved. There was a slight difference in favour of charcoal but as only 6 per cent. is the maximum damage in the number of tubers due to rotting in storage no distinction could be drawn between the effects of different manures.

Although well selected tubers from the manured plots were well preserved even without charcoal a mixed lot of tubers when stored without selection was damaged completely when no charcoal was used for storage while another lot which was also stored without selection but with charcoal had nearly 77 per cent. tubers well preserved.

As the preservation of the potato tubers in charcoal is partly meant for using them as seed, the yields of potatoes grown from tubers stored (*a*) with and (*b*) without charcoal were compared in 32 small plots measuring $22' \times 9'$ for each kind of tubers. Out of these 32 pairs of plots, in 25 plots the yield was higher from tubers stored with charcoal than the corresponding plots sown with tubers stored without charcoal ; and the average yield of the 32 plots was 14·9 per cent. higher from the tubers which were stored with charcoal than from the tubers stored without charcoal. It appears therefore that no harm is likely to result from storage of seed tubers in charcoal powder.

The reports on the storage of potatoes in charcoal according to our method from Nagpur and Cawnpore show that the potatoes used for storage at both the places could not be preserved. This effect may be due to the difference in handling which the potatoes received at the two places or the difference in variety. The potatoes stored at Pusa in this section were in almost all cases about 96 per cent. sound and had lost about 25 per cent. moisture only during storage showing that the method as carried out at Pusa eminently serves the purpose of storing the tubers till planting. A fresh experiment appears to be necessary to locate the cause of this observed difference in results of storage of potato tubers at Pusa and at other places and it has been arranged to have boxes of stored potato tubers exchanged between Nagpur and Pusa as also between Cawnpore and Pusa.

VII. PRESERVATION OF VEGETABLES

Studies on the preservation of vegetables on a domestic scale by encouraging the growth of lactic organism were continued. This year carrots were under observation. The pH of the carrots at the end of the fermentation process was found to be 3·45 and the total acidity on dry basis 20·34 per cent. The taste of the finished product was good and there was no bad smell. The organisms present were of the *Streptococcus lactis* type, showing that a normal lactic fermentation had occurred.

VIII. PLANT DISEASES

Damping of chilli seedlings.—The defoliation and death of the chilli seedlings in seed beds was found to be caused *B. resicatorium* (Doidge). Spraying with 0·25 per cent. $CuSO_4$ or 0·25 per cent. Uspulun was found to bring the disease under control.

Yellowing of sugarcanes.—A number of clumps marked out as soon as "yellowing" was observed in the new area. The clumps were then divided into separate areas for treatment with different manures. The results are given in the table.

	Number of yellowing clumps treated	Number of yellowing clumps recovered	Per cent. recovery
Control	40	4	10·0
Ammonium nitrate . . .	43	12	27·9
Potassium sulphate . . .	42	22	52·4
Kainit	13	8	61·6

The results show that the percentage of recovery of the yellowing clumps is better with the potassium salts treatment than with ammonium sulphate.

IX. PROGRAMME OF WORK FOR 1934-35

Conservation of nitrogen in soil.—Conservation of nitrogen is one of the important problems in maintaining the fertility of Indian soils. A series of experiments of growing leguminous crops in mixtures or rotation were started four years back: one adapted to the *kharif* season and the other to the *rabi* season. These will be continued and the variations in total nitrogen in the soil and the economic returns of crop will be examined.

Green manuring.—The large-scale experiment will be continued of comparing *urid* and soybean and the application of sann-hemp tops late in the season after removing the stems for fibre, with the usual method of ploughing in sann-hemp.

The experiment with Mexican sunflower will be repeated and a large scale experiment tried on the farm.

Calcium cyanamide.—The decomposition products of calcium cyanamide in different soils which nitrify calcium cyanamide much later than in other soils will be studied.

Bacteriophagy.—Search for the bacteriophage from roots of cereals will be continued and they will be studied after their isolation to find what effect they have on the leguminous nodule organisms in soils.

Dairy bacteriology.—Quantitative study of bacteria present in general milk supply at Pusa at the time of distribution and in individual cows with a view to bacterial control of cleanliness in production of milk in the dairy will be continued. Study of starters producing flavour in butter will be continued. Observations on the kind of coli present in milk supply will be made.

Bacteriology of silage.—Preparation and study of silage from different fodders with the addition of wheat *bhusa* and molasses will be continued. Study of treatment of fodders with hydrochloric acid for their preservation as in A. I. V. process will be continued.

Other investigations.—Study of the preservation of fruits and vegetables by cold storage and the effect of spices in pickles in preventing spoilage will be carried on.

X. PUBLICATIONS

Joshi, N. V. . . . . Kudzu Vine (*Pueraria thunbergiana*). (*Agr. Live-stock in India, November, 1933*).

Joshi, N. V. and Ram Ayyar, C. S. . . . . . The Azotobacter plaque test of soil deficiency as applied to some Indian soils. (*Ind. Jour. of Agri. Science, February, 1934*).

Vyas, N. D. . . . . Effect of Maize root washings on the fixation of Nitrogen. (*Ind. Jour. of Agri. Science, February, 1934*).

REPORT OF THE IMPERIAL DAIRY EXPERT

[Zal R. Kothavala, B.Ag., B.Sc. (Agri.), N.D.D.]

I. INTRODUCTION

I held the post of the Imperial Dairy Expert throughout the year.

A new feature of this official year is the decommercialisation of the accounts of the Bangalore and Karnal Farms with effect from the 1st April, 1933, but the Wellington Farm to continue the same system of commercial accounts as before. The financial results of the Wellington Farm show a profit of Rs. 7,738 during 1933-34 as against a profit of Rs. 6,629 in 1932-33. The primary functions of the Bangalore Institute and Karnal Farm are now education and research, the dairy products obtained being disposed of mainly to the military customers. As regards Wellington, although it is looked upon at present as an institution for the supply of milk to troops, it is still used as an educational centre for imparting instructions to students in hill dairy farming.

Karnal.—Due to the unusually heavy rains during the year (47·23 inches as against 30·73 inches during the previous year) the whole of the cultivation work suffered. The outturn of the crops was poor and stagnant water in the grazing area brought about Surra and other cattle diseases. The diseases were brought under control by the prompt action taken by the Veterinary authorities at Muktesar. The breeding policy of breeding pure Hariana and Tharparkar cows by mating with selected bulls of the same breeds and of weaning the calves at birth continues.

Bangalore.—There was a drop in the sales of milk during the year due to the sale rates being higher than the prevailing rates locally. The outturn of fodder was also less than the previous year owing to scanty and untimely rainfall. The policy of breeding Scindi and Gir breeds in their pure state is being continued and records of tests of milk of individual cows are being maintained as on the Karnal Farm. A disease which was new to the farm broke out amongst the cattle in the form of Haemorrhagic Septicaemia but was brought under control with the assistance of the Mysore Veterinary Department. Our thanks are due to the staff of this department who are always ready to help the Institute with advice and treatment whenever any cattle diseases occur. The educational and research work continues at this farm. The farm as usual was visited by a number of visitors who appeared to evince a keen interest in the modern processes of manufacture of dairy products and cattle breeding.

Wellington.—As this farm is still looked upon as a commercial concern its financial accounts were prepared and showed a profit of Rs. 7,738 during the year. According to the Government orders cows in milk were sent to this farm from Bangalore for the supply of milk to the military and were returned to Bangalore when dry. The breeding experiments were stopped at this Institute according to Government orders.

II. TRAINING AND EDUCATIONAL WORK

The fifth batch of students for the Indian Dairy Diploma course was under training at Bangalore during the year. Eighteen regular students and one repeat course student sat for the final Indian Dairy Diploma examination held in the last week of November, 1933. Of these 15 students passed in the examination.

Another batch of 21 students was taken for the Indian Dairy Diploma course in October, 1933, and joined term at the Imperial Cattle Breeding Farm at Karnal and was under training during the rest of the year.

Three post-graduate students were admitted for training in January, 1934.

Eight short course students for varying period completed their training during the year. Of these two undertook short courses of a post-graduate character.

Out of the 15 British soldiers admitted for vocational training on 1st June, 1933, four left the course on 30th September, 1933, as they had to leave for England and the remainder completed the course on 30th November, 1933. A fresh batch of 15 British soldiers was taken for vocational training on 2nd February 1934 and was undergoing training during the rest of the year.

Along with the Indian Dairy Diploma examination held at Bangalore the final examination was also held at the Agricultural Institute at Allahabad. Six students passed out of eight who sat for the examination.

III. ADVISORY AND PROPAGANDA WORK

Advisory and propaganda work pertaining to dairying and animal husbandry forms an important part of the activities of the Imperial Dairy Expert and as a result of this work a great impetus is being given to the dairy industry of the country. During the year under report, necessary advice and assistance was rendered to about hundred official and private individuals and organizations in the matter of development of the industry either in the course of his tours or by correspondence.

IV. EXPERIMENTAL AND RESEARCH WORK

Bangalore.—The development of Scindi and Gir breeds of cattle by selective breeding was continued.

Milking of animals by weaning the calves was continued. Experimental feeding of dairy cows with rations containing a high protein contents was continued in co-ordination with the Physiological Chemist's Section with a view to find out result in the quantity and quality of milk, lactation period, body weight, heat period, subsequent calving, etc.

Hormone injection for the stimulation of fertility amongst cattle was experimented upon on all the three farms. No definite results have yet been obtained. Milk tests of individual cows of the different herds at Bangalore and Karnal were continued.

Statistical records on the yield of butter, cream, etc., were maintained.

A systematic investigation on the method of making Surti Cheese has been started and valuable data is being obtained with a view to standardising the process. The investigation has so far yielded very valuable results.

Wellington.—The following investigations undertaken during 1932-33 were terminated in December, 1933 :—

(1) Effect of feeding bone meal on occurrence or re-occurrence of Oestrum.

(2) Daily variations in fat per cent. of milk of individual cows during lactation.

(3) Effect of feeding lucerne on milk yield.

(4) Sex ratio of calving in relation to advancement of heat at the time of service.

(5) Collection of statistics from old records pertaining to:—

(*a*) Mortality among calves in rearing them on the " weaning " system on a hill farm.

(*b*) Proportion of male or female calves born.

(*c*) Effect of heat on yield of milk.

Karnal.—(1) Breeding experiments on Hariana and Tharparkar breeds of cattle on the same lines as last year were continued.

(2) The weaning of calves at birth and their hand rearing was continued.

(3) A feeding experiment on 24 milch cows to find out the relative drying off effect of wheat *bhoosa* and rice straw was undertaken and is in progress.

(4) An experiment on the prenatal treatment of cows and heifers in calf was undertaken and is in progress.

(5) Weaned male calves used as stud bulls were found to be slow in service. In order therefore to see if bulls will improve in service if they are allowed to suck their mother an experiment is being made in this connection.

(6) Statistical information on the outturn percentages of cream, butter and *ghee* under farm conditions is being collected.

V. CO-OPERATION WITH OTHER SECTIONS AND DEPARTMENTS

This section fully co-operated with the Physiological Chemist's section in providing it with facilities required for its experimental work, in the form of cattle, feed, etc. Also, the help received from that section in conducting various experiments in the Dairy is much appreciated.

VI. ADMINISTRATION OF FARMS

The following detailed reports from the Superintendents of farms are submitted. These reports have been commented on by me in the introduction to this report.

Bangalore

During the year Mr. S. Cox was in charge of the Institute from 1st April 1933 to 4th April 1933 when he went on leave for 8 months from 5th April 1933 and Mr. A. Lamb officiated for him from 5th April 1933 to 3rd December 1933. Mr. S. Cox rejoined after the expiry of his leave on 4th December 1933 and continued to hold charge till the end of the year.

There was a fall in the outturn of green fodder from the Farm lands to the extent of 214,871 lbs. as compared with the year 1932-33 and by 284,202 lbs. as compared with the year 1931-32. The decrease in the outturn during the year was due to want of rains at the proper time. This naturally resulted in increased cost of

production. A comparative statement showing the outturn of fodder for the last 2 years is given below :—

Kind of fodder	Acreage	1933-34				1932-33	
		Outturn in lbs.	Total cost	Cost per 100 lbs.		Outturn in lbs.	Cost per 100 lbs.
			Rs. A. P.	Rs. A. P.			Rs. A. P.
Green Jowari .	56·28	1,206,400	2,507 14 8	0 3 4		1,560,340	0 2 2
Lucerne . .	·79	84,427	305 6 9	0 5 9		96,448	0 4 11
Guinea grass .	9·03	1,190,965	2,031 3 5	0 2 9		968,460	0 3 2
Rhodes grass .	·46	54,560	81 3 9	0 2 4		79,600	0 2 3
Total .	66·56	2,536,352	4,925 12 7	0 3 1		2,704,848	0 2 7
* Green Jowari	..	240,380	441 2 3	0 3 0		283,355	0 1 10
* Guinea grass	..	5,000	1 2 0	0 0 4		8,400	..
Total .	..	245,380	442 4 3	0 2 11		291,755	0 1 9
GRAND TOTAL	..	2,781,732	5,368 0 10	0 3 1		2,996,603	0 2 6

* Grown at Bommanpally.

There was a drop in the sales of both milk and butter as compared with the previous year due to the high prices of these products as compared with the local market rates. This resulted in the customers withdrawing their patronage. Further one British Infantry Regiment was using margarine as a substitute for butter on certain days in a month. For comparison the prices are given below :—

	Local Rates	Farm Rate
	Rs. A. P.	Rs. A. P.
Milk	0 1 9 per lb.	{ 0 3 0 and 0 2 6 } Mainly at As. 3.
Butter	0 14 0 ,,	1 4 0
Cream	1 0 0	1 12 0

2. As according to the Government orders the accounts of this Institute have been decommercialised since 1st April 1933 no financial results have been worked out.

(1) *Expenditure.*—Comparative figures for three years are given below :—

1933-34	1932-33	1931-32
Rs. A. P.	Rs. A. P.	Rs. A. P.
1,15,493 6 5	1,29,193 0 6	1,36,709 7 10

The decrease in expenditure as compared with the previous two years is due to economy and the purchase of some grain and fodder, more especially *ragi* straw at a lower price and further to the reduction in the quantity of butter purchased owing to the fall in the sales of Dairy Produce.

(2) *Receipts.*—Comparative figures for three years are as follows :—

1933-34	1932-33	1931-32
Rs. A. P.	Rs. A. P.	Rs. A. P.
92,426 7 9	1,16,560 10 3	1,27,077 3 2

The decrease in the receipts during the year was due to the fall in the sales of Dairy Produce as mentioned in the foregoing.

(3) *Sale rates of Dairy Produce.*—The sale rates were as under for the past three years except for butter to civilians which was Re. 1-4-0 per lb. during 1931-32.

	Rs. A. P.
Milk—	
Officers, Civilians, Troops and Hospitals	0 3 0
Married families	0 2 6
Issues at the Dairy in customers own vessel	0 2 6
Bulk for 50 lbs. and above issues at the Dairy in customers own vessel	0 2 0
Butter—	
Officers, Civilians, Troops and married families	1 4 0
Civilians from 5th February 1933 up to 31st May 1934	1 8 0
Cream—	
To all	1 12 0
Cheddar Cheese—	
Whole cheese	1 4 0
On cut	1 8 0

(4) *Establishment.*—The expenditure for three years under this head was as follows :—

1933-34	1932-33	1931-32
Rs. A. P.	Rs. A. P.	Rs. A. P.
34,974 5 0	31,834 4 0	37,372 7 0

The increased expenditure in this year as compared with the previous year was due to the reduction in the percentage of cut

in salaries of the permanent Establishment and the accrual of periodical increments in the pay of establishments as also to the pay of the officiating Superintendent being higher than the permanent Superintendent while he was on leave during the year.

3. *Cultivation.*—The same policy was followed during the year as in previous years, *i.e.*, to raise as much green crops on the lands as the irrigated water would allow. This comprises an area of about 9 acres of Guinea grass, ½ an acre of Rhodes grass and 2/3 acre of Lucerne. These crops give a continuous supply of green fodder all the year round and which is of considerable value to the herd.

The remaining cultivation area of 56 acres is used for monsoon crop, usually *jowari* and which is utilised largely for silage making.

Rotation of crops is not followed as a rule as plenty of farmyard manure is available and also because the harvesting of *jowar* is usually too late to permit of a winter crop being sown. Experiments in this direction have met with little or no success.

The only fodder purchased every year is *ragi* straw, which is not grown on the farm. It could be grown but it will be at the sacrifice of *jowar* which gives much heavier crops.

4. *Cattle.*—The herds maintained consist of cross-bred cows (*i.e.*, those sired by imported Ayrshire bulls), Scindies, Girs and Murrah buffaloes.

The feeding of the adult herd is based on the starch equivalent contained in the mixed concentrates which consist of Bran, Groundnutcake, Brewery grains and Gram Chuni in the proportion 3 : 3 : 2 : & 1. A pound of this mixture has a starch equivalent of ·53 and the Albuminoid ratio works out at 1 : 4·7.

Based on a live weight of 700 lbs. and giving milk of 4·2 per cent. butter fat a cow gets ·25 starch equivalent per pound of milk yielded *plus* ¾ pound of oilcake for maintenance. Roughages are fed on a basis of 18 lbs. dry matter fed as green fodder, silage or dry *ragi* straw in whatever proportions they are available.

The comparative overall averages of milk per day of all the animals in the adult herd were as follows :—

	1933-34	1932-33	1931-32
Cows (X Bred, Scindi and Gir) .	8·3 lbs.	9·6 lbs.	8·6 lbs.
Buffaloes	6·8 „	11·6 „	7·8 „

The less average for cows for the year under review was due to the decrease in the cross-bred animals which yield more milk than the indigenous breeds. Cross-breds are being eliminated to conform with the breeding policy followed on the farm, *i.e.*, to improve Indian breeds. The fall in the average was also due to the outbreak of foot and mouth disease on two occasions and

Haemorrhagic Septicaemia resulting in the death of some heavy milking cows. The policy of sending cows in milk to Wellington Institute and taking them back when dry also affects the overall average.

The less average for buffaloes is the result of the animals growing older every year. They are being replaced gradually.

The following figures show the merit of the different classes of animals :—

	X Breds	Scindi	Gir	Buffs.
Average daily number in herd, milking.	56	41	5	5
Average daily number in herd, dry.	19	38	6	4
Average milk yield in lb. per animal which completed its yield during the year.	66·3980	62·2770	5·1624	5·5482
Average number of days in milk of the same animals.	250	231	217	320

As the breeding policy is to improve Indian breeds and to reduce the cross-bred herd gradually the Scindi and Gir cows are crossed only by selected bulls of their respective breeds. The ½ and ¼ breds are served by Imported Bulls and those with more than ½ imported blood by pure Scindi Bulls.

Of the 81 animals including Young Stock sold during the year the majority were of the cross-bred type.

The quantity of milk produced was cows 515,343 lb. and buffaloes 20,307 lb.

Young stock.—The number of farm-bred heifers taken on as adult stock during the year was as follows :—

12 Cross-bred ; 9 Scindies and 1 Buffalo.

Rearing of Calves.—The number of calves born during the year were from Scindies 56, from cross-breds 85, from Girs 10 and from Buffaloes 3. The male calves dropped by X bred cows were given away soon after birth and the number so disposed off was 38. Of the remainder 11 male and 36 female calves died. Calves of Indian breeds are permitted to suck their dams till the milk flows but the calves of cross-bred cows are weaned 4 days after birth. Calves of all primiparous Scindi and Gir are weaned at birth. All calves are hand reared commencing with a ration of new milk which is later on supplemented by separated milk and grain rations.

In order to control services of young stock they are brought to the Bangalore Farm when about two years old from the dry stock farm and crossed by selected bulls. They are returned to the dry stock farm when in calf.

Dry Stock.—This is sent to the dry stock Farm at Bommanpally where it is kept until a few weeks before their calving, when they are returned to Bangalore.

All these animals together with the young stock kept there are fed on concentrates and fodder the whole year round, as the grazing is very scanty even during the rains.

The dry stock farm is also used for inoculation purposes.

Diseases.—There was an outbreak of Foot and Mouth disease in May 1933 and 42 animals including calves were attacked but there was no casualty. Again there was an attack of Foot and Mouth disease in August 1933 on 196 animals including calves and one Ayrshire bull ("Royal Leader") resulting in the death of 5 young stock (all ¾th bred of 1 to 6 weeks old) and the Ayrshire bull (died of after-effects of Foot and Mouth). No further cases occurred.

In October 1933 there was an outbreak of Haemorrhagic Septicaemia which affected 23 animals including good milking cows resulting in the death of 11 animals of which 9 were cows, 1 bull calf and 1 buffalo calf. Immediate action was taken to protect the herd from this disease and Mr. K. Ranganath Rao of the Civil Veterinary Department (Mysore Government) gave much assistance throughout the year and particularly in this connection. He inoculated 276 animals and protected the herd (269) with vaccine without cost to this Farm.

The deaths during the year were as follows :—

9 cows	Haemorrhagic Septicaemi
1 cow male calf	
1 buffalo calf	
8 cows	Johnes Disease.
2 cow female calves	
1 cow	After-effects of Foot and Mouth.
1 Ayrshire bull	
5 cow young stock female	Foot and Mouth.
1 cow	Pneumonia.
1 cow female calf	
2 cows	Cyst in liver.
1 cow female calf	Black quarter.
1 Do.	Suspected Anthrax.
1 Do.	Snake bite.
1 Do.	Accident.
24 cow female calves	Mostly young calves died from various causes mainly of diarrhœa and dysentery, etc.
10 cow male calves	
1 buffalo female	Died suddenly.
2 Do.	Gastritis and Impaction.
1 buffalo male calf	Impaction.

Several cases of abortion occurred among the cows of this Institute.

Wellington

Mr. H. C. Verma, I.D.D., was in charge of the Institute practically throughout the year except from 26th February to 31st March 1934 when Mr. M. C. Rangaswamy was in charge.

2. The working of the Institute resulted in a profit of Rs. 7,738 as against a profit of Rs. 6,629 in 1932-33 and a loss of Rs. 15,922 in 1931-32. It will be seen that the improvement in the financial position of the Institute was maintained.

The Institute continued to be treated as a "Depot" for the supply of Dairy produce to the Military. Cows in milk were supplied to Wellington according to the requirements of this Institute by the Imperial Dairy Institute, Bangalore, and were returned to Bangalore when dry.

The causes in brief leading to the profit during the year under review are explained below :—

(*a*) Requirements of the Military were met in full from home produced milk thereby preventing the necessity of purchasing milk from outside.

(*b*) The purchase prices of grain and fodder were comparatively lower than that of the preceding year. The purchase rate of butter was also favourable being less by an anna per pound from 1st October 1933.

(*c*) Notwithstanding the considerable fall in the total receipts for the year as compared with those of the preceding year, there was an improvement in the position. This was mainly due to the economies effected all round.

(*d*) The favourable low rates of grain and fodder purchased during the year and the reduction in the milk herd which was confined to the military requirements, also helped to reduce the expenditure under the heads : Feed of Dairy Cattle, Freight and other sundry expenses.

The following table shows the value of capital assets at the beginning and end of the year under review :—

Particulars	Value on 1st April 1933	Additions during the year	Total	Condemnations and transfers	Depreciation	Casualties	Value on 31st March 1934
Land .	10,919	..	10,919	..	..	..	10,919
Buildings .	85,975	..	85,975	..	1,216	..	84,759
Plant and machinery.	7,270	..	7,270	115	1,355	..	5,800
Live-stock .	1,040	130	1,170	20	40	60	1,050
Total .	1,05,204	130	1,05,334	135	2,611	60	1,02,528

3. *Receipts.*—The comparative figures of receipts for the last three years are set out in the table below :—

Dairy produce	1933-34		1932-33		1931-32	
	lb.	Rs.	lb.	Rs.	lb.	Rs.
Sale of milk . .	1,19,691	22,451	1,34,966	26,060	2,32,282	45,661
Butter . . .	15,915	18,507	17,706	22,138	19,567	24,472
Cream . . .	529	927	430	753	310	543
Separated milk . .	150	9	410	14	..	..
Butter milk . .	100	2	153	2	..	..
Cheese . . .	..	..	..	..	41	68
Total receipts for D. P.		41,896		48,967		70,744
Miscellaneous receipts .		2,040		2,247		3,684
Total receipts .		43,936		51,214		74,428

All the items of receipts except the sale of cream during 1933-34 show a reduction as compared with those of the preceding two years. The drop in sales was due to the discontinuance of the supply of milk to the Civil Hospital, Coonoor. Another factor which contributed to the fall in revenue was the grant of 10 per cent. discount on sales to certain Military Institutions during the year.

The increased figure under " Miscellaneous receipts " during the previous year was due to the sale of surplus stores.

On the whole the total receipts of the year indicate a drop of 14·2 per cent. and 40·9 per cent. over the two preceding years, respectively.

4. The following table shows the sale rates of dairy produce prevailing during the last three years :—

Particulars	1931-34 Rate per lb.
	Rs. A. P.
Milk—	
To Officers, troops, Regimental Institutes and Hospitals	0 3 3
To Married families	0 2 6
Butter—	
To all	1 4 0
Cream—	
To all	1 12 0
Separated milk—	
To all	0 1 0

5. *Establishment.*—Comparative costs of establishment for the last three years are shown in the table below :—

Particulars	1933-34	1932-33	1931-32
Superintendent . . .	..	..	5,400
Superviser in charge . .	1,540	1,515	..
Permanent staff . . .	4,034	3,461	5,093
Temporary staff . . .	5,351	5,511	11,421
Total .	10,925	10,487	21,914

There was a considerable decrease in the cost of establishment as compared with the year 1931-32. The reason for this decrease is due to the retrenchment of the post of Superintendent and some other establishment as a measure of economy.

The slight increase during the year under review as compared with the year 1932-33 was due to the reduction of emergency cut in pay from 10 per cent. to 5 per cent. and to increments in the pay of establishments

6. *Trade*—There was a decrease in the sales as compared with the two preceding years. This was due to the restriction of sales to the Military only. The restrictions for not supplying the produce to civilians and private institutions should be removed. It will be in the interests of the Institute.

7. The following table shows the quantities of butter purchased and that produced and the comparative prices per pound for the last 3 years :—

Years	Purchased quantity	Price	Home produced quantity	All-in-cost
		Rs. A. P.		Rs. A. P.
1933-34	9,947	0 13 0	530	3 15 2·76
	5,273	0 12 0		
1932-33 . .	15,957	0 13 0	1,805	4 9 7·04
1931-32 . . .	18,719	0 13 7	536	7 9 0

Home produced butter.—The manufacture of Farm butter was reduced to a considerable extent during the year as the total production of milk was mostly limited to the sales, resulting in less quantity of surplus milk being available for conversion into butter.

This factor and the reduction in the purchase rate of butter contributed to the reduction in the cost price of butter.

8. *Cultivation.*—The table below gives the particulars of land in acres, owned and leased by this Institute during the year.

Land	Arable		Grazing	Forest for fuel	Buildings and roads	Total
	Perennials	Seasonal crops				
Owned . . .	5·50	25·25	25·01	7·00	6·08	68·84
Leased . . .	..	20·00	29·00	..	..	49·00
Total .	5·50	45·25	54·01	7·00	6·08	117·84

The following table shows how the arable land was distributed for cultivation and the rotation that was followed :—

Kharif	Acres	Rabi	Acres
Green grass, Lucerne, Rhodes and Guinea grass.	4·50	Rhodes and guinea grass and also Berseem.	4·50
Potntoes	5·25	Potatoes	4·75
Jowar	21·25	Barley	9·50
Maize	12·75	Oats and Peas . . .	1·50
Ragi	6·50	Oats	25·25
Gram	0·50	Wheat	5·25
Total .	50·75	Total .	50·75

During the year 40 acres of land were taken on lease from the Cantonment authorities to grow our own green fodder for cattle, as the growing of fodder proves cheaper than buying in the market.

Including the leased land of 49 acres from the Cantonment Board, Wellington, the farm area was increased to 117·84 acres. The purpose for which it was utilised is shown above. Out of the 49 acres of leased land, 20 acres were put down both for Rabi and Kharif crops. The crop grew fairly well, but the outturn of maize and oats was not satisfactory for want of rain in time. Cultivation of lucerne, Rhodes and Guinea grass was continued for ensuring a regular supply of green fodder for cattle throughout the year. During the Rabi Season Barley was also grown for the supply of green fodder to cattle. *Jowar* and maize were the principal Kharif crops grown for making silage. This was very helpful in supplying the cattle with succulent fodder during the winter months when green fodder and grazing are scanty.

The table given below shows the comparative yields of crops for the last 3 years :—

Crops	1933-34 lb.	1932-33 lb.	1931-32 lb.
Rhodes and green grass . .	1,37,270	1,38,555	1,77,115
Lucerne	5,001	15,435	..
Maize	91,500	1,08,990	1,18,210
Jawar	1,44,700	1,26,655	52,125
Sunflower	..	2,400	..
Bajra	..	19,900	12,070
Wheat	52,415	11,535	..
Oats	48,300	58,140	2,36,305
Ragi	56,650	1,700	32,435
Cabbage	..	8,800	14,285
Mangolds	3,300	520	..
Barley	17,700	..	..
Berseem	3,510	..	..
Oats and Peas . . .	6,150	..	..
Gram	4,400	..	..
Total available food for cattle	5,70,896	4,92,630	6,42,545
Potatoes (Cash crop) . .	58,500	33,384	38,090
Total .	6,29,396	5,26,014	6,80,635

Jowar and maize are found to be most suitable Kharif crops both for green issues and silage and oats, wheat, oats and peas mixed during the Rabi season. These crops give large yields and are economical to grow. During the year green fodder was produced at 0-7-3 per hundred pounds as against the market rate of about twelve annas per hundred pounds.

As usual the crop of potatoes was very beneficial as a rotation as it helped in the elimination of weeds. The crop was tried both in Kharif and Rabi being a remunerative one. During the year an outturn of 5,850 pounds per acre was obtained at the production cost of Rs. 1-8-3 as against 13 annas per 100 pounds during 1932-33. The increased cost was due to the average outturn per acre being comparatively less owing to the failure of rains. The following table shows the comparative sale prices of potatoes for the last three years :—

	Rs.	A.	P.	
1933-34	2	2	5	per 100 pounds.
1932-33	2	9	5	„ „ „
1931-32	5	1	7	„ „ „

Cattle.—This farm according to the orders of Government is still considered as a Depot of the Bangalore Institute as it had no special herd of its own. Otherwise in working it is quite independent of the other. Having no cattle of its own, no breeding experiments were conducted.

The table given below compares :—

(1) Milking average per diem per head of milking cow and (2) Overall average of the year under review with the figures for the preceding year.

	Milking average per diem per head of milking cow	Overall average
1933-34	17·50	16·10
1932-33	18·35	16·13

The decrease in the milking average per diem per head is attributed to the frequent changes in the herd of cattle with varying capacities of milk yield.

The comparative production cost per pound of milk for the last three years is given below :—

	Per pound. Rs.	A.	P.
1933-34	0	3	1·2
1932-33	0	2	9·9
1931-32	0	4	8·4

The production cost for the year has gone up due to the fall in the yield of milk and also to increase in the direct charges.

There was no outbreak of any contagious disease during the year. The general health of the herd was good throughout the year. There were a few cases of abortion amongst the cows and the casualties were mostly due to Haematuria.

Education and Research.—The investigations which were taken in hand as mentioned in the annual report for 1932-33 were continued and terminated in December 1933.

Imperial Cattle Breeding Farm, Karnal

The charge of the Farm was held by the following officers, during the year :—

Mr. M. C. Rangaswamy from 1st April 1933 to 24th April 1933.

Mr. Harnam Singh from 25th April 1933 to 11th December 1933.

Mr. A. Lamb from 12th December 1933 to 31st March 1934.

The market remained generally steady, except that it was slightly unfavourable in the case of Dairy produce. The climate was generally unfavourable due to heavy rains and floods in September-October. The expenditure and receipts for the last 3 years are :—

	1931-32	1932-33	1933-34
	Rs.	Rs.	Rs.
Expenditure	1,08,144	73,060	65,105
Receipts	60,113	48,921	43,336
Net cost	48,031	24,139	21,769

The financial position shows a slight improvement over the last year, which is partly due to less expenditure in supervision charges on account of Mr. Harnam Singh officiating for Mr. Lamb and partly to competition in renting Jodhawala plot on lease for Rs. 2,200 as compared with a smaller amount previously.

Due to the storms and heavy rains during September-October a large number of trees were uprooted and this also added to the Farm receipts. There was a net decrease in capital assets due to the writing off of annual depreciation. The percentage of decrease in the comparative figures of receipts given above works out to 19 per cent. from 1931-32 to 1932-33 and 11 per cent. from 1932-33 to 1933-34. The decrease is due to the damage done to crops by an exceptionally heavy monsoon.

The comparative figures of sale rates of Dairy produce given below show a decrease. Due to the abundance of rains, the milk and its products could be had cheaper in the market.

	1932-33	1933-34
	Rate per lb.	Rate per lb.
Fresh milk	Re. 0-0-6 to 0-1-3	Re. 0-0-5·85 to 0-0-9
Butter	Re. 1-0-0 to 1-4-0	Re. 1-0-0 to 1-4-0
Cream	Re. 0-12-0 to 0-14-0	Re. 0-12-0 to 1-0-0
Cream on butter outturn	Re. 0-10-0 to 0-11-0	Re. 0-9-6 to 0-10-0
Ghee	Re. 0-6-1 to 0-9-0	Re. 0-6-0 to 0-9-0
Separated milk	Re. 0-0-3 to 0-0-6	Re. 0-0-3
Cheese	Re. 1-2-0 to 1-6-0	Re. 1-2-0

The following comparative figures of cost of Establishment will show that there was a decreased expenditure principally on account of Mr. Lamb being away on leave.

	1932-33	1933-34
	Rs. A. P.	Rs. A. P.
Pay of officer	9,840 0 0	3,258 11 0
Pay of Establishment.		
Pay of Assistant Superintendent, Indian Supervisor, Accountant, etc.	12,174 4 0	15,857 1 0
Pay of permanent non-pensionable establishment	1,360 0 0	1,418 8 0
Pay of temporary establishment	13,387 2 0	13,354 14 0
Leave salary	1,613 1 0	1,226 2 0
Total	38,374 7 0	35,115 4 0

The demand for milk and its products at Karnal is limited The produce which could not find a sale as milk, cream and butter at the Government sanctioned rates, was converted into *ghee* and sold.

The comparative sales for the last six months of the year under report as compared with those of the corresponding period for last year are given below. The decrease in the sale of cream is due to

no cream having been sold on Butter Outturn as previously. This was turned into *ghee* and accounts for the increase in the sale of *ghee*.

	Milk	Butter	Separated milk	Cream	Ghee	Cheese
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
From October 1932 to March 1933 . .	748	1,569	38	5,423	17	—
From October 1933 to March 1934 . .	2,993	2,238	..	445	1,489	30

Cultivation

Area.—After handing over 30 acres of land to Sugarcane Sub-Station and 143 acres to Botanical Sub-Station the Farm is left in charge of 1,981 acres. Out of this :—

52·5 acres are waste lands.

298·0 acres were on cash rent for grazing and raising agricultural crops.

209·0 acres were reserved for grazing.

257·0 acres were under Roads and Buildings.

118·0 acres were under Home cultivation.

1,046·0 acres were given on *Batai*.

Rotation

Home cultivated area.

Half the area was under *Juar* and half remained fallow in Kharif

Half the area was under wheat and oats and the other half was under gram in Rabi.

In Batai 2, 3, 4 and 5

Half under *Juar* and half fallow in Kharif.

Half under wheat and half under gram in Rabi.

In Batai 6 and 7

Paddy in Kharif.

Wheat and gram in Rabi.

Kharif crop

Main Kharif crops are *Juar* and Paddy.

Juar green sown in 5 Home area was converted into silage. Total *Juar* obtained was 15,26,879 lb.

The monsoon of the year was abnormal and greatly affected both kharif and rabi crops.

The rainfall recorded was 5·65 inches during June ; 9·36 inches during July ; 6·30 inches during August.

The rainfall was quite normal until on the 19th and 20 September there was a heavy down pour of 16·73 inches, an unprecedented record for Karnal. As a consequence plots Nos. 6 and 7 (Paddy Area) were flooded and the standing paddy crop was immersed in water for a complete fortnight. The grain and straw approaching maturity were very adversely affected. The grain was totally unfit for seed purposes and the straw could not be sold as its quality had deteriorated.

Rabi Crop

The heavy rains in September and a few late showers in October delayed the rabi sowing. The land was too wet to allow of any ploughing being done and the seed had to be sown in a half prepared or wet soil. Consequently the germination was poor and the resulting yield was also poor.

In the home cultivated area 16 acres were under oats. The result of the Botanical Sub-Station's oats sown as against farm oats is given below :—

Botanical Sub-Station's oats . .	Yielded 21·4 maunds per acre.
Farm oats.	Yielded 20·7 maunds per acre.

Wheat 8A. Punjab and P. 114 were sown. Last year's results of these 2 varieties were very favourable owing to favourable weather conditions. The yield was :—

P. 114	14·4 maunds per acre.
8A. Punjab	14·9 „ „ „

Similarly T. 58 gram was tried against local gram. The yield was :—

T. 58	26·5 maunds per acre.
Local Gram	23·0 „ „ „

The Botanical Sub-Station's oats were completely free from smut while the crop raised from Farm seed was affected with smut, thus lowering the yield and the quality of the grain.

Wheat 8A. Punjab lodged badly and was also affected to a certain extent by rust and loose smut while P. 114 was slightly attacked by rust and was nearly free from smut.

1933-34

Crop	Yield outturn in Home Farm.			Yield outturn in Batai, ½ share.		
	Area acres	Total yield Mds.	Average yield per acre Mds.	Area acres	Total yield Mds.	Average yield per acre Mds.
Wheat . .	41·04	622·30	15·1	387·99	1,958·34	5·0
Oats . . .	16·66	334·0	20·8	..	..	..
Gram . . .	60·84	1,389·11	22·7	573·68	3,489·28	6·1
Paddy . .	..	..	..	495·3	2,646·0	5·3

In Batai 2, 3, 4, 5 Wheat and Gram were the 2 main crops.

In No. 6 and 7 after the harvesting of paddy, wheat and gram are sown if the weather conditions permit. There is no certainty of a winter crop even when sowing is permitted, the object being to stop the growth of winter weeds and other rank grasses in the paddy field by anything it may be possible to obtain and without any financial loss to the Farm. Wheat and gram were sown in these 2 plots.

Hay Making and Silage

Grass from No. 4, 8, 9 was turned into hay.

Total hay made was 24,518 lb. silage in addition to grazing.

Average yield per acre in Batai is low because the crops of wheat and gram in plots No. 6 and 7 are always sown late and the low yield of this area lowers the average.

During the year under review, the sowings were late, and the wheat was attacked by smut and rust. Paddy remained immersed in water on account of the floods, and this accounts for a low

average yield. The comparative yield of crops for the last 3 years, is shown below :—

	1931-32	1932-33	1933-34
	Mds.	Mds.	Mds.
Grains.			
Rice (Ziri)	4,879	3,250	2,646
Wheat	2,985	3,680	1,922
Oats	..	..	55
Gram	4,022	5,731	3,481
Mustard	..	40	..
Peas	124	..	..
	lb.	lb.	lb.
Fodders.			
Green Jowar	748,985	276,164	16,200*
Dry Jowar	116,174	..	39,770
Green Maize	..	40,657	..
Dry Maize (Maize Kurby)	..	7,180	..
Hay	76,138	118,476	227,332
Bhusa (Gram, Wheat and Oats)	628,604	698,694	652,909
Rice Straw	628,604	3,332 md.	2,625 md.
Charri silage	5,870,123	1,551,840 lb.	940,836 lb.
Grass silage	..	168,388 „	364,300 „
Anjan Grass seed	..	53 „	..
Green Grass fed green	..	14,378 „	..
Poolas (Thatching grass)	..	80½ md.	..

* Major part sold standing.

The strength of the live-stock at the beginning and end of the year was as follows :—

	1-4-33	31-3-34
Cows	132	129
Buffaloes	12	15
Cow bulls	8	9
Buffalo bulls	2	2
Cow young stock female	108	115
Cow young stock male	53	51
Buffalo young stock female	7	9
Buffalo young stock male	3	5
Bullocks	26	29
Horse	1	1
Sheep—		
Ewes	32	66
Rams	4	4
Female lambs	66	52
Male lambs	2	5
Total	456	492

Increase in stock is due to the following births during the year:—

Cow calves	104
Buffalo calves	12
	116

Transfers from young stock to adults :—

Cow females young stock	15 to adult cows.
Buffalo females young stock	3 to adult buffaloes.
Cow male young stock	9 to bullocks.
Cow male young stock	1 to bulls.

Disposals—

(1)	Cows	13	Were sold away due to old age, poor records and incurable disease as Johnes disease, etc.
	Buffaloes	*Nil*	
	Bullocks	2	
(2)	Buff. male	1	Were sold to private parties.
	Cow males	4	
(3)	Cow calves female	23	These were condemned some at birth and some at an early age due to the following causes—
	Cow calves male	26	
	Buffalo female calf	1	
	Buffalo male	*Nil*	

(*a*) Low Dam records; (*b*) Not conforming to the type ; (*c*) Colour ; (*d*) Underweight at birth ; (*e*) Physical deformations.

Overall average milk yield of different breeds on Farm

Year	Tharparkar lb.	Hariana lb.	Buffalo lb.
1931-32	7·8	7·6	10·4
1932-33	9·3	8·4	13·0
1933-34	9·4	8·6	11·8

A comparison in overall average shows only a slight increase in the cow herd over previous years. This is due to ill-health on account of severe outbreaks of Surra and Foot and Mouth diseases during the best part of the year (September, October, November and December).

As regards buffaloes the decrease is due to (*i*) outbreak of Surra, (*ii*) advanced age, (*iii*) no new heifers completing their lactations.

Breeding

The main object is to select and grade breeds of high milking strain on the Farm. As regards sheep they are made use of for manuring purposes as their feed costs practically very little to the Farm.

The following tables show the improvement done in breeding since 1923-24 to 1933-34 :—

	Tharparkar Herd		Hariana Herd	
	Purchased	Farm Bred	Purchased	Farm Bred
Average milk yield lb.	2,235·5	3,650·6	2,256·0	3,636·0
Average lactation period in days . . .	239·9	307·0	251·0	317·0
Average days dry . .	147·2	88·9	151·0	82·0
Average overall . .	5·5	8·8	5·3	8·7

Average milk yield of animals which completed their lactation in 1933-34

	Average milk yield lb.	Average No. of days in milk	Average days dry
Tharparkar	3,973·5	304	106
Hariana	3,805·0	300	102
Buffaloes	6,212·0	348	131

Results of selected breeding from the comparison of overall average for 3 years and percentage of increase/decrease each year for all breeds.

	Tharparkar		Hariana		Buffaloes	
	Overall average	Percentage of increase	Overall average	Percentage of increase	Overall average	Percentage of increase
1931-32 . . .	7·8	26	7·6	35	10·4	22
1932-33 . . .	9·3	23	8·4	23	13·0	25
1933-34 . . .	9·4	1	8·6	2	11·8	9 Decrease.

Records of six best animals of each breed which completed their lactation during the year were as under—

Serial No.	Animal No.	Age	Milk yield	Days in milk	Remarks
		Y. M.	lb.		
			Tharparkar		
1	215	9 4	5,588	306	Farm bred.
2	216	10 1	5,903	433	Do.
3	240	9 3	5,785	451	Do.
4	301	7 10	7,224	439	Do.
5	306	7 6	5,846	375	Do.
6	323	8 0	5,709	308	Do.
			Hariana		
1	108	14 0	5,872	317	
2	142	13 6	6,028	359	
3	270	10 0	5,553	282	
4	276	8 10	5,189	349	Farm-bred.
5	349	7 2	5,187	307	Do.
6	427	5 2	5,148	441	Do.
			Buffaloes		
1	31	5 4	6,670	413	Farm-bred.
2	39	7 8	7,754	411	Do.
3	40	7 8	7,001	391	Do.
4	42	7 7	5,064	241	Do.
5	45	6 7	7,395	373	Do.
6	48	6 5	7,748	326	Do.

No production cost of milk has been worked out by the auditors. Its working out appears to be of little value on this Farm, as the milk here is a bye-product and not a commercial product. The animals are maintained to meet the requirements of research and experiments.

Young stock.—15 cow heifers and 3 buffalo heifers calved during the year.

Rearing of Calves.—The system of weaning calves at birth is followed as a rule except in cases where Farm-bred animals fail to give milk up to expectations as the progeny of high milking dams. Such unweaned calves are tied before their mother during their milking time and are pail fed. This system of unweaning has proved very effective in a majority of cases.

Calves up to the age of one month only get pure milk and after this age it is gradually substituted by separated milk and after 6 months of age they get only separated milk.

Mortality.—4 cow calves ; 3 buffalo calves ; 6 lambs.

Dry stock is kept mostly on grazing and on a maintenance mixture ration until 2 months before they are due to calve when they are separated from the other stock and special care is given to them.

Diseases.—The following deaths occurred during the year:—

Cows	4 (1 from Surra, 3 from old age and other natural causes).
Female young stock	6 (1 from snake bite, 2 black quarter, 3 from other causes).
Male young stock	4 (3 from Surra and 1 from other causes).
Bullocks	4 (2 from Surra, 1 from Johnes disease and 1 old age).
Sheep	10 (From Gid and old age).

There were severe outbreaks of Foot and Mouth and Surra diseases during the months of September, October and November. 72 animals were affected with Foot and Mouth diseases which lasted from 12th October 1933 to 7th December 1933. Milking stock, bulls and male youngstock were badly affected with Cattle Surra which prevailed from 22nd September 1933 to 16th November 1933. Up to the 3rd week of October the infection was in a mild form but afterwards it spread in all the herd and then the help of the Muktesar Research Institute and the Investigating Officer of the Veterinary Department, Punjab Government, was sought. The causes of these epidemics were the outbreaks of foot and mouth, Surra, rinderpest

and Haemorrhagic Septicaemia, in the neighbouring villages and the city. The infection therefore also reached the farm.

Serum simultaneous method of inoculation was carried out by the Muktesar Veterinary Research Department. 85 animals were inoculated (48 youngstock females, 26 youngstock males, 3 cows and 8 bullocks).

Experiments and Research

Tests to determine the butter fat and solids-not-fat quantities were conducted and are being continued for the combined herd of the three breeds on the Farm and also for individual animals of the different breeds under the following heads :—

(1) A combined herd test for the two breeds of cows separately and of buffaloes daily morning and evening.

(2) Individual animals of the two breeds for one complete lactation daily morning and evening.

(3) In making the above tests a few exceptions had to be made from the daily tests to alternate days so as to reduce the volume of work, as this was proving too much for the existing staff.

(4) The individual animals who had completed the period of one full lactation under the above test were brought under weekly composite test and for which morning and evening proportionate samples were collected daily separately, preserved and tested once a week.

The number of animals under the above tests at the beginning and close of the year is given below :—

Description of Tests	Tharparkar		Hariana		Buffaloes	
	31-4-33	31-3-34	1-4-34	31-3-34	1-4-33	31-3-34
Daily . . .	40	18	33	15	3	1
Alternate days . .	..	12	..	13	..	8
Weekly . . .	..	16	..	14	..	..

Total on 1st April 1933 . . . . . 76 animals.

Total on 31st March 1934 . . . . . 97 ,,

The above includes the combined herd tests for all the breeds.

The accompanying table would give an idea of the capacity for fat production of the three different breeds of animals during the year.

Breed.	Total No. of animals in milk	Total fat produced in the year in lb.	Average per head in lb.
Tharparkars . . .	18,387	10,491·5	·57
Harianas . . .	16,148	10,088·3	·62
Buffaloes . . .	3,291	3,872·7	1·17

The highest yield of fat was produced by cows in July 1933, and by buffaloes in March 1934.

The compilation work was greatly handicapped on account of the shortage of staff.

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